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NOTICE TO AUTHORS OF PAPERS

1. Forwarding Address. Papers intended for publication in THIS JOURNAL should be submitted to Neil E. Gordon, Editor, The Johns Hopkins University, Baltimore, Maryland.

2. Manuscript. The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

3. References and Footnotes. Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

4. Illustrations. Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

Photographs should have a gloss finish and should be at least post-card size—larger, if possible. Only prints which are unblurred and which show sharp contrast between light and dark areas can be satisfactorily reproduced.

Line drawings should be carefully prepared in black ink on plain white drawing paper or blue drawing cloth, twice or three times the size desired in the printed cut; it is convenient, when permitted by the scale required, to have them the size of the manuscript. When coördinate paper is used, it should be printed in blue only, with the important coördinate lines ruled over in black; the black square should in general not be less than ten millimeters on a side; the lines of the curves should be the heaviest, except the frame; points on the curves should be indicated by true circles, not crosses. The numbering of the coördinate axes, the number of the figure and any necessary explanations of the figure should be written in pencil in the margin of the sheet, as they are usually set up in type rather than reproduced from the drawing. All lines, numbers, and letters that are to be reproduced are to be so proportioned that they will be clearly legible in the cut.

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All photographs, line drawings, and tables should be provided with self-explanatory titles or legends. Each illustration should be marked in pencil on the margin with the name of the author and the title of the article to which it refers.

Kindness of Dr. R. B. Wetherill

CHARLES MAYER WETHERILL, REPRODUCED FROM A CRAYON PORTRAIT

EDITOR'S OUTLOOK

Charles Mayer Wetherill

IN THIS issue we begin the publication of Dr. Edgar Fahs Smith's last biographical study. The manuscript, which remained unfinished at the time of Dr. Smith's death, has been revised and completed by Dr. C. A. Browne. We believe that in inviting Dr. Browne to undertake this labor of love Mrs. Smith made a wise and fortunate choice. She could scarcely have found another whose sympathy with the author, whose interest in the subject and whose scholarly attainments so well fitted him to complete creditably and to make available to the public this last contribution of Dr. Smith to American chemical history.

Charles Mayer Wetherill, the subject of this biography, affords an interesting study in himself—his part in the development of American chemistry was somewhat greater than has been generally recognized. As Dr. Browne has pointed out, however, his life is of even broader interest as a cross-section of his period in American chemistry. It is a source of pride and satisfaction to us that the JOURNAL OF CHEMICAL EDUCATION has been granted the privilege of presenting this article to its readers.

Honor Where Due

ON MAY 4th, the American Institute of Chemists paid tribute to two persons who have undoubtedly accomplished more for the advancement of American chemistry than any other laymen have been privileged to achieve. The occasion was the presentation to Mr. and Mrs. Francis P. Garvan of a medal commemorating their many services to the science and the profession. Those services are too extensive and too varied to receive adequate comment here. The speakers who graced the event have dealt more ably with that subject than could we, and their addresses are published in full elsewhere in this number. We desire only to commend most heartily this graceful acknowledgment of a great and public-spirited work and to endorse the expressions of appreciation and regard which accompanied it.

The Student Exhibit

THE last meeting of the American Chemical Society included several features of especial educational significance. The one to which we desire to direct attention at the moment, however, is the exhibition of students' work arranged upon the suggestion of Charles H. Stone and under the supervision of Dr. Jesse E. Day. The exhibit was accumulated upon comparatively short notice and without benefit of any intensive efforts at promotion, yet a

highly creditable showing was made, as the list of exhibits beginning on page 1153 of this number demonstrates.

Teachers of chemistry have long been theoretically convinced that to attain anything approaching a full measure of success, chemical education must provide for and encourage a greater degree of self-activity on the part of the pupil. Particularly is this true in our courses in elementary general chemistry, where the vast majority of our students are actuated by no professional urge and where the single course must succeed or fail on its own intrinsic merits. To most of our elementary students we cannot reasonably say, "This course is dull and dry in parts and much of it will have no immediate significance for you, but you must master it in order to be prepared for what comes after." We *can* continue to ladle out the conventional, pre-professional course and, armed with the power of the flunk, we can accomplish a certain amount of forcible feeding, but the regurgitation which occurs on examination day is complete. No trace of intellectual nourishment is absorbed into the student's system. Such conservatism, such insistence on "good, hard study of real chemistry, with no diverting superficialities included," may constitute a sincere tribute laid upon the altar of the science, but it cannot, by any stretch of imagination, be construed as education. It is not the function of a teacher of general or cultural chemistry to make public obeisance to chemistry, or even, primarily, to "teach chemistry;" it is his function to employ chemistry as a means toward the cultural and intellectual development of his pupils.

Most teachers, as we have said, are willing to concede their assent to these principles. Some give evidence through their teaching that they are in reality actuated by such ideals. But the transition from the older teaching to the new will not take place overnight. We are only pioneering as yet. And there is a great deal of pioneering to be done.

The employment of student project work of various kinds has already given evidence of much promise. In the hands of a good teacher the project is a potent source of interest; it necessitates original and creative effort on the part of the student and it induces him to put forth that effort willingly and gladly. It affords the pupil an opportunity to experience the satisfaction of pride of workmanship and, if his work is afterward exhibited, the additional satisfaction of public admiration and approval.

But the project is no miracle worker. If it becomes the victim of faddists and extremists, it will suffer discredit which will seriously diminish its usefulness. Interest and student initiative are not ends in themselves, but means toward an end. No doubt the best intentions and coolest judgments will meet with failures and reverses before they arrive at any moderately satisfactory scheme.

In the meantime, we are pleased to note that experiments in this field

are being widely undertaken and that a similar exhibit is to constitute one feature of the Minneapolis Meeting. Manufacturers of chemical apparatus and products, high school, and college laboratories and other agencies which are interested in chemical education are invited to send exhibits. Free exhibition space will be reserved upon request to the Local Secretary, Dr. H. H. Barber, School of Chemistry, University of Minnesota, Minneapolis.

Educational "Movies"

ONE of the most interesting events of the recent meeting of the American Chemical Society and, certainly, the best-attended program sponsored by the Division of Chemical Education was Dr. Langmuir's talking motion picture, demonstrating the effect of surface films on liquids. The picture was notable not only because it was an exceptionally fine example of the educational film, nor because of the interest of the subject matter, but because it gave fresh impetus to the already growing recognition of the educational potentialities of the moving picture.

For convenience we may arbitrarily divide educational moving pictures into two classes—first, those prepared for general use, but which may also be well adapted to classroom needs, and, secondly, those devised primarily for classroom showing. As yet, the available films of which we have personal knowledge seem to fall almost entirely into the first class. At the present time, however, several studies looking toward preparation of classroom films are being conducted, and at least one of those contemplates the inclusion of chemical topics.

No doubt many teachers are asking themselves just what are the possibilities of the moving picture in the chemistry classroom. Already we are using films to a certain extent to demonstrate practical application of chemistry and chemical industrial processes. Can the moving picture play an important and helpful part in teaching the fundamentals of chemistry? If so, how shall it be employed? How much chemistry can be presented by means of pictures?

If we may justifiably hazard an opinion upon a subject with which we have had so little first-hand contact, we would say that it seems probable to us that the greatest immediate progress will result from adopting the attitude that the moving picture is not so much a new medium of presentation which can be employed to teach all of chemistry, as a new and supplementary technic offering special advantages for the treatment of certain special topics. What are some of the advantages exclusive to the moving picture? The first which occurs to us (and one of the greatest) is that it can be made to portray action which no human eye ever beheld at first hand. All who have witnessed the animated cartoons of the moving picture theater will realize the significance of this

statement. The teacher, or at least the film-maker, can convey much more clearly than he could by means of words, or with the aid of blackboard diagrams, a knowledge of events which he has never actually seen save in his mind's eye. The army has taken advantage of the animated diagram to teach the inner working of the machine gun and other arms. The chemist can show what goes on inside impressive but (to the student) meaningless units of plant equipment. He can portray the operation of primary, secondary, and electrolytic cells. He can demonstrate the principles upon which many instruments employed by physical chemists operate. In short, the potentialities of the animated diagram are almost unlimited.

A second advantage of the moving picture is that it enables all the members of a class to gaze simultaneously through the eyepiece of a microscope or similar piece of apparatus. Where the class is large this means that demonstrations otherwise impossible may be conducted; in the case of a small class it means an enormous saving of time. There is also the further advantage that one motion picture camera and a few films can be substituted for many pieces of expensive apparatus which teachers might like to employ in demonstrations but all of which few individual schools could afford to own. Except where classes are extremely large or where the lecture room is entirely unfitted for demonstration work we would hesitate, however, to recommend the film as a substitute for demonstration work in general.

No doubt the moving picture possesses other characteristic advantages. One more which we would like to point out is that it permits an organization of subject matter which is difficult to attain by other means. In the course of one illustrated lecture it is possible to proceed without distraction or loss of time from theoretical diagrams to laboratory demonstrations and thence to industrial operations. Related subjects widely separated in time and space may be brought together and their relation emphasized.

The successful use of the moving picture in chemistry teaching will involve the answering of two questions—or perhaps of the same question posed in two different ways. What unique advantages of the moving picture can be used to supplement our older methods of presentation? Or otherwise put, what deficiencies in our present methods is the moving picture especially adapted to overcome? Here, it seems to us, is one new tool to add to our kit—but not a new kit of tools to replace the old.

The commercial success of the amateur movie camera with its comparatively inexpensive film offers the individual teacher an opportunity to do a little experimenting on his own account—if he cares to ride hobbies so closely related to his daily work. We venture to predict that some of the best (from a pedagogical standpoint) films will be evolved in this manner.

THE TECHNOLOGY OF TANNING

GEORGE D. MCLAUGHLIN AND FRED O'FLAHERTY, RESEARCH LABORATORY OF THE TANNERS' COUNCIL, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

We usually regard as a commonplace the leather of our shoes, our luggage, the belts which transmit power, and the upholstery of furniture and automobiles. Seldom does any one inquire as to how leather is made, nor do they realize that an understanding of the scientific principles or laws which underlie tanning is rendered very difficult because of the complexity of the materials used in making leather. And yet the very complexity of the field has been the means of drawing to it, in recent years, many chemists, bacteriologists, and histologists.

The owners of the leather industry of the United States came to realize, some eight years ago, that in order to further improve their product and to protect their large investment, the scientific laws of the materials and processes of their industry must be written. They meant scientific laws in the fullest and best sense of the term and hence built upon the campus of the University of Cincinnati a handsome and well-equipped research laboratory and provided funds for the prosecution of its work. And they entered into an agreement with the University of Cincinnati which stipulated that only fundamental scientific work would be pursued, that the research workers would be free to choose their problems and that the results of all investigations would be published in reputable scientific journals. They do not regret their investment, since work which at the start seemed to be of purely theoretical interest has eventually enabled the more progressive members of the industry to produce more and better leather from a unit of raw material. In other words, this undertaking has simultaneously provided funds for scientific research and has produced wealth and better leather.

Before proceeding to our discussion of tanning, the reader may be interested in knowing something of its history. Tanning was very probably the first manufacturing process of man, since tanned skins served primitive man both as clothing and armour. All of the ancient literatures and mythologies contain interesting references to animal skins, tanning, and leather. Skin was often used in early times to designate secular or religious rank; that of the lion, for example, signifying the highest rank and that of smaller, less regal animals, such as the wolf, denoting a lower rank. The student of scientific history is interested to find that the scientific phases of tanning attracted such men as Paracelsus, Lavoisier, Humphry Davy, Berzelius, Liebig, and Emil Fischer. It is only during the past twenty years, however, that a serious, systematic study of the science of tanning has been undertaken. This delay has been due not merely to the complexity of the field but largely because the older the

industry the slower is its realization of a need for science, whereas the younger industries—such as telephony, auto-transportation, and many others—were born of science rather than of empiricism.

Tanning is, of course, the conversion of the readily putrescible animal skin into the imputrescible leather which is so durable a compound that it is often found in the oldest Egyptian tombs in a remarkably good state of preservation. After passing through a number of preliminary or preparatory processes in the tannery, the skin is "tanned" by being treated with an aqueous infusion of vegetable tannin or, in the case of the so-called "mineral" tannage, with a solution of chromium or aluminum salts.

Most of the leather used for shoe soles or belting is "vegetable" tanned with the water extractive of certain barks, woods, roots, nuts, or leaves. The active principle of this extractive is called "tannin," which is a general term describing a group of organic substances about which little is known except that they all seem to be derivatives of the di-hydric phenol, catechol, $C_6H_4(OH)_2$, or the tri-hydric phenol, pyrogallol, $C_6H_3(OH)_3$. The tannins have been justly termed the *dark continent* of organic chemistry. The outstanding work in this field was done by that great chemist, Emil Fischer, who succeeded in synthesizing one of the tannins. The tannins are colloidally dispersed in aqueous solution.

The bulk of shoe upper and the lighter leathers are chrome tanned, that is, they are treated with a solution of a basic chrome salt of the general composition: $Cr(OH)(SO_4)_2$. Chrome leather is a much more stable compound than is the vegetable tanned; the former withstands the action of boiling water, whereas the latter is quickly hydrolyzed by such treatment.

Heavy leather, such as sole, is made from the skin of matured animals, as the steer or cow, while light leathers come from younger or smaller animals, such as the calf, sheep, or goat. Novelty leathers are made from a great variety of skins—ostrich and snake, for example.

There are six major processes or steps in tanning: (1) death of the animal and removal of the skin from its carcass, (2) curing or preservation of the skin, (3) soaking, (4) unhairing, (5) tanning, and (6) finishing. These process steps may best be understood by means of enlarged microphotographs, as shown in Figures I to XI, where the skin or leather has been photographed in cross-section. The skin of a steer has been selected for these illustrations because its great thickness renders it well suited for illustration and because it is, in general, typical of all animal skin, including the human. The pictures represent a magnification of about twenty times.

The slides from which the pictures are photographed are prepared as follows. A small piece of the specimen is placed in a ten per cent formalin solution; this "fixes" the tissue (in much the same manner as when a body

TANNER'S RESEARCH LABORATORY

is embalmed) and delays further changes in its structure. After twenty-four to forty-eight hours the fixation is complete. The specimen is then surrounded by water and quickly frozen by means of carbon dioxide gas. The resulting frozen tissue, embedded in its block of ice, is shaved by means of a very sharp knife (microtome). The shavings or "sections" are about 20 microns ($^1/_{1250}$ inch) thick. They are then stained with dyes. Certain dyes stain only one skin component. Thus, by properly selecting the dyes, several may be used on the same section and the different structures will become apparent due to the difference in their color after staining. The section is then freed of any excess dye, dehydrated by treating it with alcohol, is cleared in xylol, and is then made permanent by mounting it in Canada balsam between two pieces of glass. The finished section may then be studied under the microscope or may be projected, greatly magnified, upon a screen.

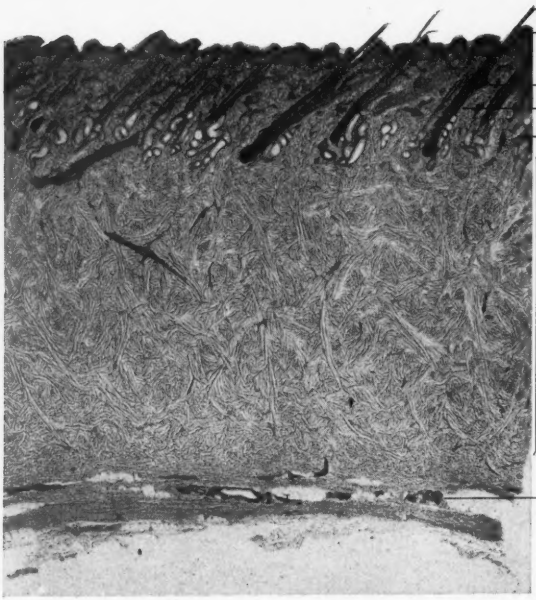

FIGURE I.—FRESH SKIN

Figure I shows skin obtained immediately after the animal's death and prepared as described above. The dark line marked *A* represents the epidermis which covers the outer or free surface of the skin and extends downward, lining the hair follicle. Epidermis is very similar chemically to horn and nail and is composed of water and the protein keratin together with small amounts of lipins and inorganic salts. The hair, *B*, is seen to extend below the skin's surface and to rest in a pocket or follicle formed by the downward extension of the epidermis. At *C* are seen the sack-like fat glands which are associated with the hair. This is shown and explained in greater detail in Figure II. At *D* we note

PRIVATE LABORATORY OF PROF. G. D. MCLAUGHLIN, DIRECTOR

DR. J. H. HIGHBERGER, IN CHARGE OF CHEMICAL WORK

the erector pili muscle; one of these muscles is attached to the wall of the follicle of each hair. When this muscle contracts and shortens, it draws the attached follicle and hair into a more nearly vertical position; this phenomenon is very strikingly seen in the cat's hair when menaced by a dog, and to a lesser degree on our own skin when we experience a chill and have "goose-flesh." At *E* we observe the sweat glands which appear, in the picture, as a series of large holes, because these glands have a tortuous contour and when the microtome blade cuts the thin sections shown it passes through the gland at the numerous points of intersection. The bulk of the weight and thickness of the skin is comprised by the part of the section marked *F;* this is termed the corium or dermis. Histologically, the corium is made up of interlacing bundles of fibers which are seen to be poly-directionally arranged; it is due to this structure that skin possesses great strength and toughness, both before and after tanning. The fibers are surrounded by and bathed with a liquid protein which is somewhat similar to egg-white and, like it, is easily coagulated by heat or dehydration. Throughout the entire corium are seen dark specks or spots which are the nuclei of the cells from which come the material which forms the fibrous structure. The corium is plentifully supplied with blood vessels of varying size; an artery is seen at *G*. At *H* is seen the loose fatty tissue which connects the skin proper to the animal's carcass.

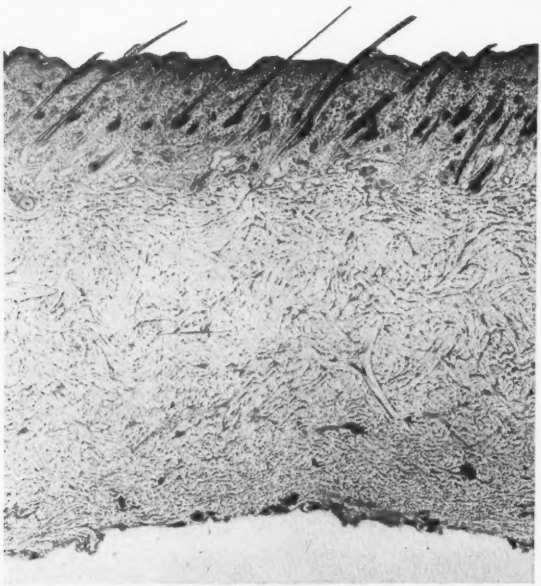

FIGURE II.—SHOWING SKIN FAT

Considered chemically, the corium is composed of about sixty per cent water, the bulk of the remainder being the protein collagen together with smaller quantities of the proteins albumin, globulin, and mucoid. There

Dr Fred O'Flaherty, in Charge of Histological Work

Dr. G. E. Rockwell, in Charge of Bacteriological Work

is, also, a small amount of carbohydrate (glycogen) together with fatty bodies (lipins) and physiological salts. Collagen is closely related to gelatin, since if collagen is boiled with water it is converted into gelatin.

Figure II shows the same skin which has been dyed with a stain having a selective action for the fatty substances of the skin, as shown by the red color in the picture. We now see the fat glands referred to previously and that the gland secretes fat into the follicle, from which it finally reaches the outer surface of the skin. It is to be noted that but little fat has been stained in the lower eighty per cent of the cross-section. As a matter of fact, however, this area contains a large amount of fat but the fat is not "free" and hence does not stain. It is combined with the corium protein and is not extractable therefrom with ordinary fat solvents until the combination (whether chemical or physical is not yet settled) has been broken and the fat liberated. This liberation may be brought about by the action of either dilute acids or proteolytic bacteria upon the skin; the latter action often occurs accidentally in manufacturing practice. The fat of the steer skin is not unlike beef tallow, in general, except that it contains varying quantities of lecithin and cholesterol.

FIGURE III.—SHOWING ELASTIN FIBERS

Figure III shows another structural component of the skin: the elastin fibers. They appear, after staining, as the bluish black threads or lines running parallel with the skin's surface and seem to be attached at their ends to the hair follicles. These fibers are of a pale yellow color when unstained and are of an elastic, rubbery nature, and possess the ability to stretch under strain and to resume their normal length when the stress is removed. No completely adequate explanation of their function has

been advanced but our own belief is as follows: when the erector pili muscle is stimulated and the hair is pulled into a vertical position the elastin fibers attached from hair follicle to hair follicle are stretched. Then, when the muscular contraction is completed and relaxation occurs, the elastin fibers tend to return to their normal length and thickness and in doing so pull the hair back into its normal position and angle. It will be noted that the bulk of the elastin fibers are found in the upper twenty per cent of the skin's thickness, with only a small amount occurring in the lower portion of the skin.

All animal skin is heavily infected on its outer surface with proteolytic bacteria and during slaughter and skinning blood and other organic bacterial food are deposited on the skin. Under these conditions the bacteria begin to rapidly digest the dead skin and the speed and extent of their attack is greatly stimulated by warm temperatures. The packer must, therefore, quickly treat the skin in such a manner that digestion will be minimized: this process is termed "curing." Curing consists of impregnating the skin with sodium chloride, which partially dehydrates the skin and acts as an antiseptic.

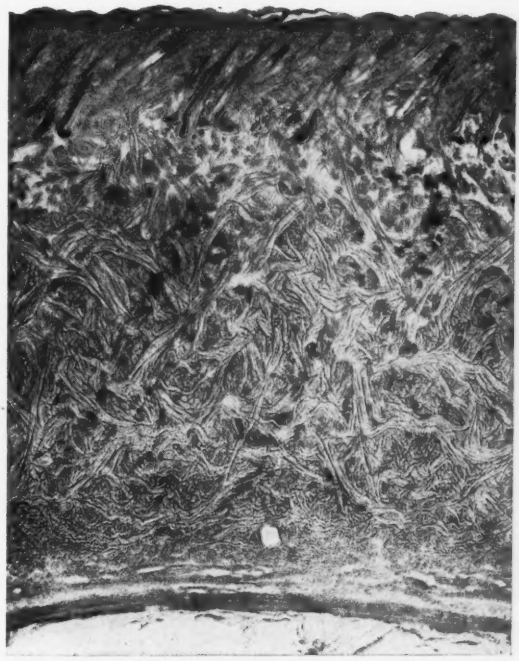

FIGURE IV.—SHOWING DESTRUCTIVE ACTION OF BACTERIA

Figure IV shows the structural change which bacteria bring about in skin which has been allowed to stand uncured and unprotected for thirty-six hours at 20°C. (68°F.). This section has been cut at an oblique angle so that the digestion around the hair may be better seen; this digestion appears as the open spaces between the periphery of the hair and the surrounding skin. The epidermis is seen to have been digested in

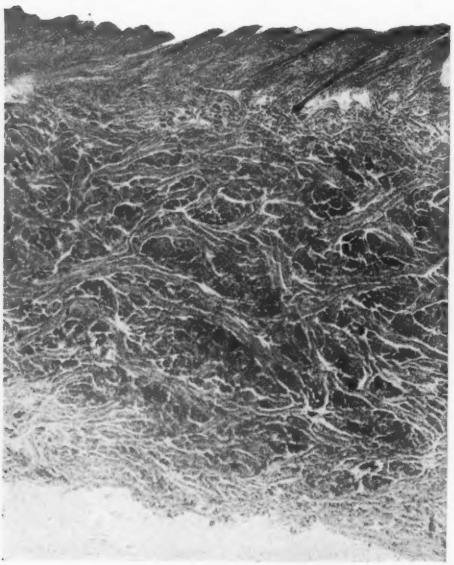

FIGURE V.—CURED SKIN

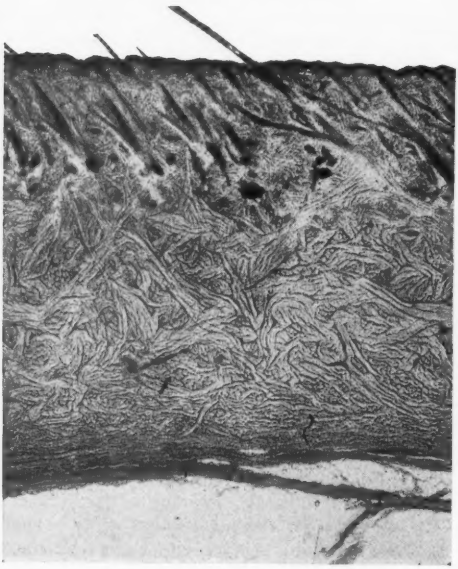

FIGURE VI.—SOAKED SKIN

spots, and open spaces appear between the epidermis and the underlying skin layers. A skin which has suffered the damage shown is of little value for leather.

The laws which underlie the whole process of curing are now well known and have enabled packers to produce a better product, for which they receive an increased price. The procedure which has been evolved as the result of the study of these laws is, in brief: the fresh skin must be washed free of blood and filth promptly and must then be immediately immersed in a cold saturated solution of sodium chloride for about sixteen hours, then removed and allowed to drain for, say, thirty minutes, and then spread out in piles with a layer of clean salt uniformily distributed between each skin. Heavy hides should be allowed to lie thus "in pack" for about thirty days, two weeks being sufficient for light skins such as calf. If this procedure is not followed the unchecked post-mortem changes in the skin rapidly reduce its ultimate value by impairing the ability of the skin to

"swell" in subsequent tannery processes and by the actual decomposition of the skin proteins and consequent loss of leather-forming material. Any damage done to the skin at this point cannot be undone by the tanner, regardless of his skill.

A well-cured hide is pictured in Figure V. This is quite unlike the fresh hide (Figure I) in appearance, because the dehydrating action of the curing salt has so shrunken and contracted it that the various structures are no longer plainly seen. But we will be able to recognize them again in Figure VI.

The cured hide is now shipped to the tannery and the tanner gives it the first of the tannery processes: "soaking." Soaking, as the term indicates, consists of placing the salted skin in water, the purpose being to rehydrate and soften the skin, remove its curing salt and surface filth and, in addition, to remove the now partially coagulated (due to curing dehydration) egg-white substance which, as we have learned, surrounds the corium fibers. If this partially coagulated substance is not removed the fibers remain cemented together and thin, poor leather results, whereas if it is removed, the individual fibers are separated and a better tannage and leather quality results. This partially coagulated protein is only slightly soluble in plain water but is quite soluble in dilute salt solutions: hence the importance of the tanner's proper regulation of the amount of soak water he uses, since this determines the dilution of the sodium chloride (the curing salt) in his soak.

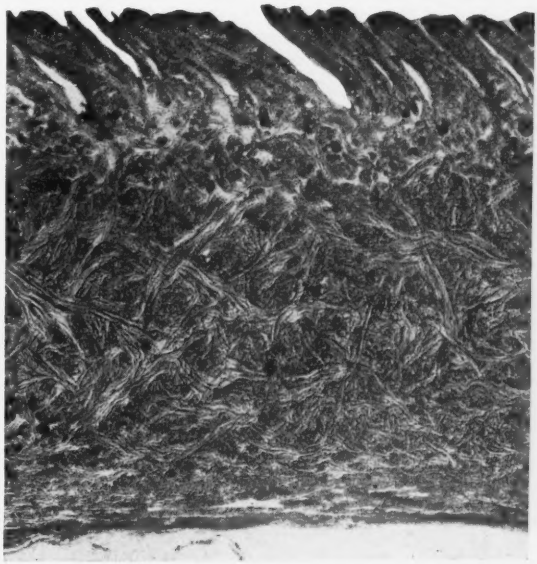

FIGURE VII.—LIMED AND UNHAIRED SKIN

Figure VI shows the hide after proper soaking. The various skin structures are once again apparent and the corium is now hydrated and swollen.

The laws which govern soaking have also been established and they have shown in practice that the physical objects already enumerated must be attained with a minimum of chemical change in the soaked skin and that any marked change in the skin's composition results from bacterial digestion in the soak. Such digestion is prevented by using cool soak water, reducing the time of soaking to less hours than the lag period of the soak bacteria and by having a salt concentration present in the soak which will restrain bacterial growth. The proper concentration is obtained by regulating the amount of water used. When the soaking is completed the salt must be washed out of the soaked skin, so that it will not interfere with subsequent processes.

FIGURE VIII.—SLIGHTLY TANNED SKIN

The next process—that of unhairing—is of extreme importance to the tanner and of very great interest to the leather scientist. It consists, in brief, of placing the soaked skin in an alkaline solution in which it remains until the epidermis (see Figure I) has been so decomposed by the alkali that it, together with the hair, may be easily removed by mechanical means. This is brought about in practice by placing the skin in a saturated solution of calcium hydroxide for about one hundred and twenty hours at 20°C. In addition to its unhairing action, the lime partially saponifies the skin fat and brings about certain chemical changes in the skin protein which are necessary for the skin's satisfactory reaction with tanning materials. Lime is the alkali employed, not merely because of its cheapness; its limited solubility renders it a fool-proof material in the hands of workmen. Sometimes the action of the lime is hastened by the addition

to it of sodium sulfide, but the use of sodium sulfide results in damage to the valuable skin corium.

Figure VII shows skin which has been treated with lime as described above and has then been mechanically "unhaired." It is seen that the epidermis (both of the free surface and that lining the follicle) is gone, the hair follicles are now empty and the fibrous corium is well swollen by the action of the alkaline lime.

Chemists, bacteriologists, and histologists had long puzzled over the mechanism of the unhairing process and only recently has the question been satisfactorily answered and improved manufacturing practice made possible. Argument had centered around: (*a*) whether the liming is purely chemical in nature, (*b*) is it necessary that bacteria be present in the lime solution, and (*c*) are the skin enzymes which the soaked skin always contains necessary for the process, the lime, itself, functioning as a co-enzyme? It has now been proved, however, that neither bacteria nor enzymes function in liming and that the process is purely chemical. It was shown, however, that the extent to which bacteria act upon the skin *before* it enters the lime solution determines, to a very large degree, the skin's chemical behavior in the lime.

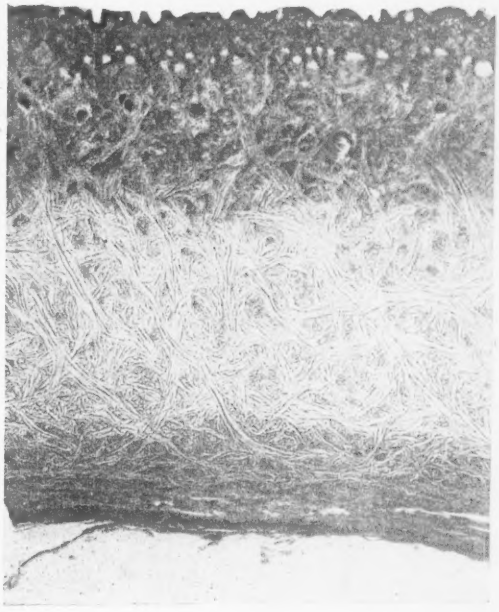

FIGURE IX.—PARTIALLY TANNED SKIN

Another very baffling question was simultaneously solved. It had long been the practice of tanners to use the same lime solution a number of times, that is, for successive lots of skins. They found that such a practice produced what was termed a "mellow" lime; the mellower the lime the more rapidly it unhaired the skin. And yet curious anomalies were often found in producing mellow limes in the tannery: sometimes they did not

become "mellow" and, again, mellowness would develop with great rapidity. Leather scientists endeavored unsuccessfully to explain mellowness through the presence of bacteria, enzymes, or ammonia in the lime. The real explanation is now found to be the presence of small quantities of primary amines (chiefly methyl amine, CH_3NH_2) in the mellow lime. The amines are produced by the action of proteolytic bacteria upon the skin proteins during curing or soaking, or in both. Due to their small concentration in the lime solution and to certain similarities with ammonia, they had been overlooked. They function as catalysts, speeding up the reaction between the lime and the keratin of the epidermis. And they catalyze the reaction between the lime and the collagen of the corium, as well. It is possible to now explain the anomalies which the tanner encountered in producing mellow limes: if the skin undergoes marked bacterial decomposition before entering the lime much amine is carried into the lime solution and mellowness results; if, on the other hand, bacterial digestion is minimized little amine formation ensues and mellowness is not attained. It will be noted, of course, that the mellow limes of the past have been obtained by the tanner through bacterial destruction of valuable skin substances: the discoveries just described will enable him to preserve the skin by preventing bacterial digestion and to produce the mellow lime synthetically, by adding methyl amine to fresh lime solution.

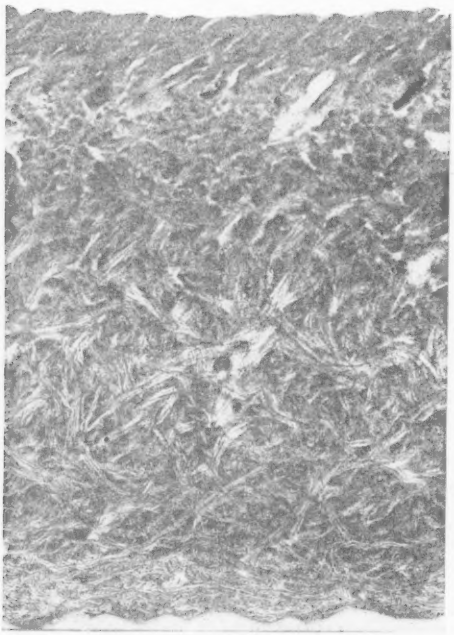

FIGURE X.—COMPLETELY TANNED SKIN

The hide is now ready for the tanning process proper, for conversion into sole leather. It is treated first with a very weak infusion of vegetable tannin which, in this particular tannage, was derived from a mixture of the tannin of American chestnut wood, quebracho wood from Argentine, and the bark of the chestnut oak tree of the southern states. The strength

of the solution (or "tan liquor") is gradually increased until after a number of weeks the hide no longer absorbs the liquor components and is then said to be tanned. As pointed out, the first tan liquor is very weak since if a strong liquor were employed it would tan the outer surfaces of the hide so completely that the colloidal tannins could not diffuse into and tan the interior of the hide. It is necessary therefore to "feed" the hide slowly in order to obtain a thorough tannage.

Figure VIII shows the hide after the third day in the tan liquor. The section of this figure (and those in Figures IX, X and XI) has not been artifically stained, the brownish shade noted being merely the color of the tanned or partially tanned hide. Figure IX shows the hide after fourteen days tanning and we note the center of the hide is still untanned. The fiber bundles of the corium stand out in bold relief like strands of rope running in all directions. Figure X illustrates the fully tanned leather. This is now treated with oil, to lubricate the fibers and to enable the tanner to produce an attractive leather surface or "grain." The leather is then hung up to dry. After drying it is dampened and mechanically compressed, in much the same way that clothes are dampened and ironed: this compression increases the solidity of the leather. The finished leather is shown in Figure XI.

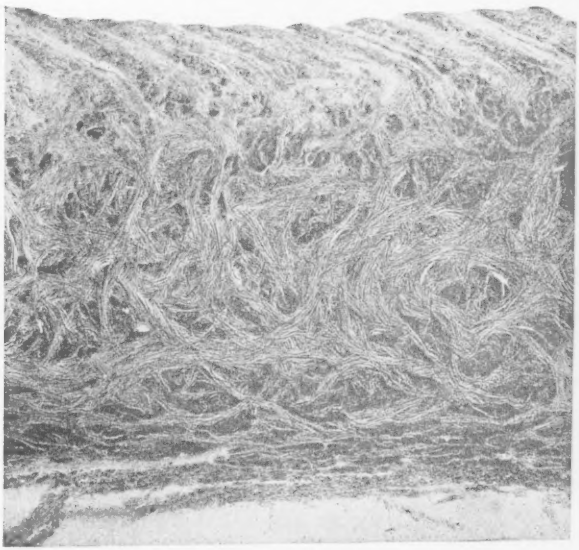

FIGURE XI.—FINISHED SOLE LEATHER

The processes of producing mineral-tanned light leathers differ somewhat from those described and illustrated for the vegetable-tanned heavy sole leather, but the processes for producing all classes of leather are similar in principle and the space required to describe them all would not be justified.

The nature of the reaction between tannin or mineral salts and skin substance is still unknown. Many interesting theories as to the reaction have been advanced and much experimental work has been performed in an effort to support or disprove them; the whole question is still, however, quite unsettled. It is improbable that any really fundamental progress in this particular problem will be made until a clearer knowledge of the chemistry and physics of the skin proteins is gained. We believe, however, that at that time mineral tanning (chrome, at least) will be found to be a purely chemical reaction and that in vegetable tanning we deal first with an adsorption of the tannin bodies by the skin, followed by a slow chemical reaction.

Many interesting scientific problems in the ancient industry of tanning remain unsolved, problems which are attracting many younger men of science. These problems are interesting not alone in themselves but because of the important bearing their solution will have in pure science, in various technical fields and in many phases of medical science. We will instance only a few of the questions which must still be answered. (1) What is the actual mechanism of the swelling which occurs when skin (or any other protein tissue) is subjected to the action of acids or alkalies? (2) What is the structural arrangement of the protein molecules of skin? (3) In what manner do electrolytes and non-electrolytes combine with skin? (4) What is the structural arrangement of the molecule in the various solutions of chrome salts used in tanning? (5) What is the composition of the vegetable tannins and to what extent does their degree of dispersion in aqueous suspension influence their action on skin? How may their dispersity be controlled?

Aside from its purely scientific interest, tanning is of importance to the general public which wears and uses leather. Good shoes are an important item in the world's economy and human health. And to the industrialist, whatever his specific interest may be, there is a useful lesson to be learned in the fact that so old an industry as leather manufacture has found that the substitution of science for empiricism has a sound economic basis and is, indeed, its only safe means of preservation.

Museum Shows Motion of Smoke Molecules. New Yorkers can now see the motion of the molecules in smoke which they breathe or exhale. A new exhibit at the Museum of the Peaceful Arts in New York makes this visible. The visitor blows a puff of cigarette smoke into a funnel, where it passes under a high power microscope. Under the microscope, tiny smoke particles can be seen vibrating back and forth. This motion is caused by the bombardment of the particles by the constantly moving molecules of air around them, and is known to scientists as the Brownian movement.—*Science Service*

AWARD OF AMERICAN INSTITUTE OF CHEMISTS*

In opening the recent meeting of the American Institute of Chemists, Dr. Frederick E. Breithut, the national president, spoke as follows:

The American Institute of Chemists welcomes you. We are here met to do honor to Francis Patrick Garvan and Mabel Brady Garvan. With characteristic objectivity and self-effacement, Mr. and Mrs. Garvan have asked that as little as possible be said about them personally and that as much as possible be said about the importance of the science of chemistry to human welfare and progress.

We shall respect their wishes.

If human progress can be gaged by the extent to which man has substituted mastery of his environment for slavery to it, then chemistry has played a major rôle in human advancement and the recipients of our medal have been true contributors to progress.

If the noblest contribution of science to humanity is not so much the enhancement of man's material welfare and comfort but the freeing of the human spirit from the bondage of ignorance, superstition, prejudice, and bigotry, then our medalists are true servants of science. They have amply demonstrated their worthiness to have bestowed upon them, with our heartfelt gratitude, this simple token, this symbol of our appreciation, which in the cold and formal language of our constitution is awarded "for noteworthy and outstanding service to the science of chemistry and the profession of chemistry in America."

The nature of the outstanding service of Mr. and Mrs. Garvan and its noteworthiness will be detailed to you by wiser men than I. My sole function is to present the presiding officer of this meeting. Were I merely to catalog the achievements of our chairman, I might be accused of fulsome flattery by those unacquainted with the facts of his life, if such there be. But I am sure our chairman values more highly than all else, the respect, the affection, and the love of his colleagues which we so genuinely feel for him.

Ladies and gentlemen, you surely must know my inadequate words are attempting to describe Dr. Charles Holmes Herty.

* An announcement of this award to Mr. and Mrs. F. P. Garvan was made in the February issue of THIS JOURNAL, **6**, 337–40 (1929.)

In the following pages are contained the addresses made on the occasion of the presentation of the medal to its recipients at the auditorium, Engineering Societies Building, New York City, May 4, 1929.

Fear not that thy life shall come to an end, but rather fear that it shall never have a beginning.—*Cardinal Newman*

Wide World Photo

PARTICIPANTS IN PRESENTATION OF AMERICAN INSTITUTE OF CHEMISTS' AWARD, MAY 4, 1929

H. S. Nieman, *Secretary* F. E. Breithut, *President* J. J. Abel J. H. Finley C. H. Herty
J. W. Davis Mabel Brady Garvan Francis Patrick Garvan

ADVANCE OF THE NATION THROUGH THE SCIENCE OF CHEMISTRY

CHARLES H. HERTY,* 101 PARK AVENUE, NEW YORK CITY

In every purposeful gathering of human beings some determining note, some all-pervading spirit, prevails. On this happy occasion, when we are met to pay honor to Mr. and Mrs. Francis P. Garvan, I feel that, despite the welter of lack of public understanding, of the bitter legislative struggle, and of the fierce judicial battles through which we have come during the past twelve years, there hovers this evening over this assemblage the gentle spirit of a lovely little child, Patricia Garvan, whom death claimed while the best of medical skill strove in vain.

When Mr. Garvan became head of the Bureau of Investigation of the Alien Property Custodian's office, he soon learned, through the ably conducted research of Mr. Joseph H. Choate, Jr., of the thorough grip which German industrialists had gotten upon the business life of America. From first-hand evidence, gained through the seizure of official documents during the War, he saw at once the endeavor, through the prevailing economic distress, through the shortage of dyes and the suffering of our people through the lack of accustomed medicinals, to utilize this industrial advantage as a political club to mold the policies of our Federal Government in matters bearing upon world welfare. All too evident were the handicaps placed upon the development of our Army and Navy by the very privileges allowed through our Patent Office. Later, through public sale of a large group of these patents there was presented the probability of the creation of an American monopoly through concentration of these patents, and the further possibility of their eventual return to their former owners with a consequent revival of the obnoxious conditions of the prewar period. This led to the creation of the Chemical Foundation, Inc., an organization which former Senator Wadsworth of New York State has fitly classed as the greatest piece of constructive thought of the war period.

Soon after the creation of the Chemical Foundation an interview which I gave to Mr. Edward Marshall was printed in a large number of Sunday newspapers. This interview emphasized a more intensive application of research to problems of health, setting forth the empirical character of much of our medical practice of today and the great lack of public understanding of the tremendous significance of a greater application of science for the relief of suffering and the prevention of premature death. Soon after that interview appeared I received a request from Mr. Garvan to call at his office, and as I walked in I noticed on his desk a copy of a Pittsburgh paper containing this interview.

"Doc," he said, "this appeals to me more than all the questions of eco-

* Chairman.

nomics and ethics with which I have become so familiar recently."

We were interrupted, however, by an important government call and it was arranged that I should visit him at his home the following Sunday. There, in the privacy of his home, he told me of their grief over the helpless loss of little Patricia and of his determination to give of his time, his means, and his energy without limit in the hope of being instrumental to some degree in saving other parents the suffering and sorrow through which his family had just passed.

That motive lay a secret between us for several years. I know of no greater sacrifice for the public good than that which Mr. and Mrs. Garvan have made in laying aside their private grief in order that the spirit of little Patricia should lead humanity to a higher and more useful goal.

It may be well, on this occasion, to bring together and to record a few striking incidents which marked the unusual struggle to arouse this nation to the importance of chemistry in its application.

On May 20, 1919, President Wilson in his message to Congress included this striking paragraph:

> Nevertheless, there are parts of our tariff system which need prompt attention. The experiences of the war have made it plain that in some cases too great reliance on foreign supply is dangerous, and that in determining certain parts of our tariff policy domestic considerations must be borne in mind which are political as well as economic. Among the industries to which special consideration should be given is that of the manufacture of dyestuffs and related chemicals. Our complete dependence upon German supplies before the war made the interruption of trade a cause of exceptional economic disturbance. The close relation between the manufacture of dyestuffs on the one hand, and of explosives and poisonous gases, on the other, has given the industry an exceptional significance and value. Although the United States will gladly and unhesitatingly join in the program of international disarmament, it will, nevertheless, be a policy of obvious prudence to make certain of the successful maintenance of many strong and well-equipped chemical plants. The German chemical industry, with which we will be brought into competition, was and may well be again a thoroughly knit monopoly capable of exercising a competition of a peculiarly insidious and dangerous kind.

Reading this, I realized at once what a change had taken place in the mind of the President. In 1915, while President of the American Chemical Society, I had sought an interview with him, determinedly, but in vain, in order to present just this point of view to him. It is not difficult to guess through whom he did receive enlightenment on this subject.

It was a common thing in those early days for those of us who stressed the close relationship between the manufacture of dyes and poison gases to be called propagandists in the most obnoxious sense of the word. However, full justification of our contention was set forth during the hearings on the Longworth Bill, H. R. 2706, a measure introduced in the House of Representatives by Congressman, now Speaker, Longworth, who, from the very outset, had recognized the importance of the chemical industry to

national defense. As the oral hearings proceeded and printed copies became available there was suddenly revealed, on page 210 of these hearings, the official "Report of the British Mission Appointed to Visit Enemy Chemical Factories in the Occupied Zone Engaged in the Production of Munitions of War." This commission was accompanied by representatives of France, Italy, Belgium, and by six distinguished officers of our army. This report had been shown to some of us in confidence and carried ample conviction. How it got into the printed records is not shown, but the report giving details of production of poison gases by tonnage and by kind in each of the German chemical factories sealed forever the lips of those who sought to belittle those arguments.

Perhaps one of the most dramatic incidents of this whole legislative period occurred one day at the hearings held by the Senate Finance Committee during the testimony of Mr. Joseph H. Choate, Jr. Matters had been going along in a more-or-less humdrum way when suddenly the question turned toward the delicate subject of graft as practiced by the German dye industry. Mr. Choate referred to the universal prevalence of such corrupt practice and, upon being questioned for more specific information, he raised from the table a copy of the *Quarterly Review* and read from an article on "German Business in the United States." The author of this article, Mr. Burr, was sitting in the committee room. In this article Mr. Burr gave an account of the internal friction between the two groups of the dye industry over reimbursement of one group "for something like $700,000 for 'graft' payments made in the United States." Objection was made by the other group solely on the question of the character of the form of the vouchers. After much squabbling, the final result was that the meeting "entered on its minutes the following resolution: 'RESOLVED, that henceforth bribery should be abolished, except in the United States and in Russia.'" (Page 99 of the *Hearings*.)

The reading of this remarkable document in the presence of its author and the absence of any denials created a sensation and satisfied all as to the prevalence of such corrupt practice in the dye industry.

As we think of the appreciation of chemistry today in this country and of the fostering care of the government in these latter years it is almost incredible to recall a scene at which I was present in the office of Dean Edward Gay, a member of the War Trade Board. Some seven or eight of us called on Dean Gay to enlist his interest in support of the dye industry by a continuation of the powers of the War Trade Board until Congress should have an opportunity to pass protective legislation. An earnest plea was made but we found we were faced by a marble heart, for with haughty mien and in a most emphatic manner Dean Gay assured us that the powers of the War Trade Board for such purposes would be exercised only to the minimum extent—but he missed his guess, for as a result of the

educational work that was done the War Trade Board did extend its protection, and for a long period it was the only protection, to the American dye industry.

During all of this period Mr. Garvan proved himself an aggressive fighter and a wise counselor, for he recognized that to bring about those conditions which would realize his ultimate aim in the application of chemistry to the solution of the problems of health it was necessary first of all to create and preserve permanently an American dye industry which would serve as a post-university school for our chemists, and he insisted that in so far as legislation was necessary to secure such a complete and permanent industry we must rely primarily upon a sound and well-informed public opinion. To aid in the development of such a national understanding the Chemical Foundation began the distribution of pamphlet literature throughout the nation. It was realized, however, that there was badly needed a readable popular book on chemistry. Such a book was found in Dr. Slosson's "Creative Chemistry" and arrangements were promptly made with the publishers, who cheerfully coöperated, for the purchase of a large number of copies of this book, many of which were distributed gratis to thoughtful people in every part of the country and the rest were sold at actual printing cost. Thus began the work of public education.

From the gallery of the Senate I watched, one day, Senator Knox reading that book throughout a day's session. He had caught the meaning of it all and especially the relation of the industry to national defense. This proved important. For a critical moment arose when the War Trade Board was about to pass out of existence, funds for its continuance were exhausted, and the American dye industry was faced with the possibility of destruction. At this time the Emergency Tariff Act of 1921 was before the Senate Finance Committee. Representatives of many industries appeared and sought to have their products included in this protective measure, but with uniform unfavorable response from the committee. At the very close of the hearings, however, Senator Knox appeared before the committee and with a brilliant statement on the necessity of the dye industry for national defense he secured an incorporation in that act (Title 5) which transferred the War Trade Board Section to the Department of State and which gave a prolongation of these restrictive powers on imports, not only of dyes but of all synthetic organic chemicals. But the opposition of the importers was busy too and it succeeded in cutting down the time limit of this extension of the War Trade Board's powers. It was a thrilling moment in Congress one night when this time limit was about to expire and Congress was about to adjourn. All day Senator Wadsworth had striven to secure a vote on a resolution for further extension but not until the hands of the clock showed five minutes of twelve was that vote obtained and the American dye industry thereby saved.

Pressure of another sort was brought to threaten disaster to the young industry. The problem of the production of vat dyes had proved very great. Meanwhile, prewar supplies of this particular group of dyes were practically exhausted. The shirt makers were in great trouble. A conference was held. On three days' notice I was hustled off to Paris and London, with the approval of President Wilson and with the financial expenses borne by the Chemical Foundation, to take part in conferences with the Germans looking to a partial distribution of impounded dyes prior to signing the Peace Treaty. Only after reaching Paris did I learn of my belated appointment as a representative of the State Department. The dyes were secured and we should always value the services of the Textile Alliance, its president, Mr. A. M. Patterson, and the unselfish services of three representative consumers of dyes, Mr. Franklin Hobbs, Mr. Henry B. Thompson, and Mr. Frank Cheney, who acted on a committee advising with the War Trade Board throughout this period of restricted importation, a period when such service did not add to one's popularity among one's associates. But they always stood by.

It was a long and bitter struggle to secure from Congress that full measure of protection which the industry needed. Many a time during that fight have I seen representatives of the industry completely discouraged. Into the conference room would come Garvan, electrifying the atmosphere, putting fresh fighting spirit into all, and sharing that fight side by side with the manufacturers. His fighting spirit would not down. His sincerity proved itself when the Senate adopted the resolution introduced by Senator King of Utah directing the Judiciary Committee to investigate the question of monopoly in the American dye industry. In the discussion which led up to the adoption of this resolution and throughout the hearings in both the House and Senate grave charges had been made against the Chemical Foundation. Just as soon as the announcement was made that Senator Shortridge would be the chairman of a sub-committee to carry out this investigation Mr. Garvan, as President of the Foundation, wired the senator offering to appear without subpoena and to place in the hands of the committee immediately all the records of the Foundation. What a strong commentary on the character of this struggle is the fact that after months of exhaustive investigation with every opportunity offered for placing all material in the record, the chairman of that committee stated on the floor of the Senate that not one particle of proof had been presented to the committee to support the charge of monopoly. But the investigation, fortunately, cleared the atmosphere of the many false statements which had been going the rounds and poisoning the minds of our people. The result was the building up of warm and friendly support in Congress.

But the sinister opposition was not through. The recovery of the American markets was too great a task and soon the highest authorities of our

country were enlisted against those who would serve this country through the preservation of its industry. Suddenly, out of a blue sky there came a thunderbolt. A letter from the President of the United States addressed to the Alien Property Custodian, Thomas W. Miller, instructed him to bring suit under the direction of the Attorney General, Harry M. Daugherty, to recover the patents sold to the Chemical Foundation under the authority of President Wilson. Then there was shown the real fighting spirit of Garvan. Without hesitation he declined the request made of him and then began that long period of litigation in the Federal Courts. I do not need to remind you that the outcome of that affair was a complete rejection of every item in the Bill of Complaint of the Government, which decision was unanimously upheld by the United States Court of Appeals and finally, after a masterful presentation of the Foundation's case by Honorable John W. Davis, was unanimously sustained by the Supreme Court of the United States. It is a matter of history and of no little moment that one of the afternoon papers in New York City on October 11, 1926, carried, in adjacent columns, two striking articles; one, the news item from Washington giving the decision of the Supreme Court in the matter of the government's suit against the Chemical Foundation; the other a local newspaper item giving the decision of a Federal Jury convicting Thomas W. Miller on the charge of conspiracy in failing to give his government his best services, and the acquittal of Mr. Harry Daugherty of the same charge through a vote which proved to be one juryman out of twelve.

One of the most stirring moments in the history of the American Chemical Society was the wave of enthusiasm which swept over its Council at a meeting in New Haven which greeted the announcement of the offer of Mr. and Mrs. Garvan to finance a Prize Essay Contest to be conducted under the auspices of the Society in the high schools of every state in the Union. Immediately it was recognized that here was the start of a great educational movement. The marked success of this undertaking, enlisting as it did the interest of prominent men and women in every State, led to a subsequent extension of the offer to include similar contests in all the colleges, and still later in the normal schools of the nation. Here was a concrete method for the teaching of pandemic chemistry throughout the nation and an assurance that our future citizens would be informed as to the important rôle which chemistry plays in national affairs. The beginning of this work, however, showed a total lack of popular chemical literature in our schools suited for junior use. This need led to the extension of the Chemical Foundation's idea of distribution of popular books and, with fine business ability, there was made quickly available a set of five books chosen by a committee of the American Chemical Society and sold at a remarkably low price. But the need was too great to wait for selling. Some 20,000 sets of these books were, therefore, given by the Foundation

to the high schools of the country. The need of the essayists was not yet filled. There was a loud call for popular books on chemistry in industry, in agriculture, and in medicine. This led to one of the finest exhibitions of American spirit, for, recognizing the altruistic work of the Foundation and inspired by its zeal for popular education in chemistry, a host of the ablest scientists of the country gave, without charge, their time, energy, and experience to the preparation of chapters on these subjects, and so the list of books grew, and public understanding increased daily.

Industry, however, had been somewhat slow in embarking on research developments. The pleas of national defense, economic independence, fell, more or less, on deaf ears. Then was it decided to issue another plea on the simple theme that research pays. Under the authorship of Hugh Farrell, the Foundation issued a pamphlet entitled "What Price Progress!" written in the language of the investing public and pointing out clearly that research must be the guide to efficient operations and to new developments. Half a million copies of this pamphlet were distributed gratis. Immediately there came a response and we were launched upon a new industrial era. Later this pamphlet was enlarged to a book which is today carrying its full measure of helpful influence.

Time does not permit of a detailed statement of the multifold activities of the Chemical Foundation. Its general policy has always been to utilize such funds as were available for stimulating others to do more. Direct aid was given to such institutions as Harvard, Johns Hopkins, Princeton, and other universities in the preparation and distribution of literature in campaigns for funds for new laboratories. Through a small contribution for research on sewage increased interest in many states was aroused, more funds made available and finally a journal devoted to this particular subject was founded.

The shortage of biological stains, obtained previously entirely from Germany, proved a serious handicap to laboratory workers in biological sciences throughout the nation, thereupon the Foundation coöperated with a commission of the biological societies. The result is that today the country is supplied with a domestic source for this very necessary product, of far finer type than those of prewar days, and interest in this subject is continuously maintained through the medium of a special journal on biological stains.

Aside from popular education, the Foundation has spent its earnings for the direct support of chemical effort and through its close contacts it has been able to find those needs which do not easily find public recognition and to strengthen important lines of work needing financial assistance. Following this policy it has assisted in financing such publications as the *Journal of Physical Chemistry*, the *International Critical Tables*, and the JOURNAL OF CHEMICAL EDUCATION. This latter modest little publication has, through

such assistance, been developed into an important journal bearing materially upon the work of the teachers of chemistry throughout the nation. The Foundation's gifts have enabled the American Chemical Society to so enlarge the pages of its publications that the great output of chemical research work from our laboratories could find prompt record. Not content with such efforts in behalf of the teaching of chemistry, Mr. Garvan has gone further and made possible the establishment, in Johns Hopkins University, of a department devoted to the teaching of chemistry. In giving direct aid to research a particular field has been chosen to which scant attention has been given by others, that is, definite lines of chemical research as applied to the sickness of human beings. Realizing the importance of such research to each individual citizen, it has heartily assisted in arousing public sentiment on behalf of federal legislation, as embodied in the Ransdell Bill, which seeks, through the creation of a National Institute of Health, to amplify the research program of the United States Public Health Service. It is a fair prophecy to predict that this important measure will be enacted during the life of the present Congress.

Such a program, gifts and pledges, naturally will exceed the income of the Foundation as its patents gradually expire but there is no anxiety about the full execution of these pledges for in each case Mr. Garvan has given assurance that, should the income of the Foundation be not sufficient, he guarantees their full payment through his personal means.

I have talked with many Europeans about this remarkable man who, trained not in science but in the law, has nevertheless proved himself one of the great educators of our day, for he has educated a nation in a way unique, and has given an impulse to that recognition of the value of research which is sure to prove one of the great agencies for stabilization and forward movement among the forces at work in our country.

His voice has always been lifted up for America. Every proposition submitted to him had to meet that requirement. No prejudice of section, race, or creed ever moved him. In recognition of his outstanding assistance he has been made an honorary member of the Synthetic Organic Chemical Manufacturers Association, of the Salesmen's Association of the American Chemical Industry, and of the Chemists Club. It is peculiarly fitting that at this time the American Institute of Chemists, an organization which has primarily to do with the status of chemists, should award its medal to this man and his gentle wife who, for more than a decade, have unceasingly given time, thought, energy, and means to the advancement of the welfare of our country through the science of chemistry and its multifold applications in industry.

The raw material of truth is facts.—HERBERT HOOVER

CHEMISTRY IN RELATION TO MEDICINE

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I. Introduction

I deem it a great honor to be present on this occasion and to have the privilege before an audience of such distinction of paying my personal tribute of respect and admiration to Mr. and Mrs. Garvan. I feel commissioned also to speak for those investigators in the biological and medical sciences whose researches have been forwarded by the enlightened generosity of Mr. and Mrs. Garvan.

Doctor Herty has told you of their tireless and unselfish labors in connection with the Chemical Foundation, of their large donations toward the support of chemical journals, of the publication by the Chemical Foundation of numerous popular treatises in hundreds of thousands of copies in which the significance of chemistry for the industrial life of the nation, the advancement of medicine, and the improvement of the health of our people are convincingly set forth.

But Mr. and Mrs. Garvan have not confined their gifts to the promotion of chemical science along the lines outlined by Doctor Herty. With a wisdom and understanding that are rarely encountered among laymen, they have seen clearly that the medical sciences, if I may be permitted to speak of them as such, are connected in a very fundamental manner with the sciences of physics and chemistry, sciences which, both from the practical and theoretical point of view, are in a more highly evolved and rational state than the biological and medical sciences. The reasons why physics and chemistry have attained this higher state are that, generally speaking, the problems dealt with by these sciences are less complex in their nature, that is to say, their variables are fewer in number, and quantitative measurements, the ultimate aim of every science, are more easily made and vastly outnumber those that now prevail in the biological and medical sciences.

II. Present Dominant Position of Chemistry in Relation to Medicine and Biology

The present dominant position of chemistry in relation to the biological and medical sciences may be said to date from the discovery of the fixed gases in the atmosphere about 160 years ago. This period fell, roughly speaking, in the days of the American Revolution, when there took place also a revolution in chemical and physical ideas whose ultimate significance for our present industrial system, for our physical welfare, and even for the character of our abstract and philosophical thinking, has been of equal, if not of greater importance, than were the political events of that time. Consider for a moment that before that time the true nature of combustion, say of wood or coal, the manner in which the cells of our body burn up the

food we eat, the true significance of every breath we take, the nature of the marvelous chemical processes in the leaf of plant and tree and in their rootlets, and a thousand and one other processes that go on in the life about us, whether in the bodies of bacteria, invisible to the naked eye, or in more highly organized forms of life, were only dimly surmised but not understood in the sense in which these mysteries are now disclosing themselves to our mental vision. The discovery of oxygen in the air we breathe, by the Swedish chemist, Carl Wilhelm Scheele, and the English non-conformist clergyman, Joseph Priestley (1771–1774) (who, by the way, was "accounted a heretic" in his country and who found an asylum in America and continued his researches at Northumberland in Pennsylvania from 1794 until 1804, the year of his death), started scientists on the right path toward an understanding of living processes. In every department of science a discovery, be it of physical, chemical, or morphological character, which at the time appears to be of only trifling significance to the uninitiated but which always originates in a mind that burns with a desire to explore the unknown, may alter the face of the globe and affect in countless ways not only our own lives and those of our domestic animals but may also be fateful for our most dangerous and virulent microscopic enemies and their numerous hosts, such as mosquitoes and other insects.

I am saying nothing new, then, in declaring that chemistry has had an influence of incalculable value in the development of every department of medicine and biology; especially during the past 50 years has this influence been most significant, as it has been also in agriculture and its allied interests—the animal and dairy industries, horticulture, economic entomology—in the metallurgical, chemical, ceramic, textile, and a hundred other industries.

I venture to repeat, therefore, that there is not a single one among the many modern divisions of medicine and surgery that is not dependent to a greater or less degree on the chemical sciences, whether it be in the elaboration of innumerable diagnostic tests, protective sera and vaccines or in the preparation of a host of valuable remedies which either relieve distressing symptoms or effect a cure by destroying an invading and harmful microscopic organism.

It must not be forgotten, however, that medical science has scored many great triumphs, the primary impetus to which is traceable less to chemical and physical ideas than to the labors of microscopists, botanists, zoölogists, pathologists and clinicians. I may refer here to the comprehension and mastery, in greater or less degree, of infectious diseases such as smallpox, cholera, yellow fever, bubonic plague, typhus fever, and other scourges that have in the past decimated mankind, not to speak of syphilis, tuberculosis, leprosy, malaria, anthrax or splenic fever, the hookworm disease, typhoid fever, diphtheria, tetanus, and certain other infectious diseases as

poliomyelitis, scarlet fever, and measles, that concern us more directly than does the bubonic plague or Asiatic cholera. Our knowledge in regard to some of these diseases is not so complete as it is in respect to some of the others, as, say, diphtheria and tetanus.

III. Infectious Diseases and Chemical Methods of Combating Them The Revolution in Surgical Practice. Anesthesia

But even in this broad field of the infectious epidemic diseases in which living microscopic forms are the causative agents, chemical science always plays an important rôle, even though it be of a less spectacular character than that of bacteriology and protozoölogy. It is the chemist's part to disclose the true nature, say, of the diphtheria toxin, of antitoxins and vaccines, of tuberculin and other substances secreted by bacteria or stored in their bodies; it is his task also to determine the nature of the chemical processes and the character of the chemical substances that arise during fermentation and putrefaction, and, generally speaking, in all instances in which microörganisms play a rôle; he prepares dyestuffs with which the microscopist stains the bodies of bacteria or the cells of our tissues that have been invaded by them; he prepares innumerable antiseptics, anesthetics, alleviative and curative drugs.

The true significance of these and other examples of the chemists' contributions to the biological and medical sciences is not always apparent even to the recipients of these gifts. Consider but one of these contributions, the synthesis of dyestuffs, which at first thought might appear to supply medicine with technical aids of only minor importance. "Who could have dreamed in 1856 that Sir William Perkins' production of the first aniline dye should be an essential link in the development of modern biology and therefore in the crusade against tuberculosis and other infectious diseases? As Robert Koch has said, it would have been quite impossible for him to have developed his methods and made his discoveries without the possession of selective dyes for staining bacteria, and no other class of coloring agents has been discovered which can serve as substitutes for the anilines in this regard." (Wm. H. Welch, "The Interdependence of Medicine and Other Sciences of Nature," vol. iii, p. 315, Papers and Addresses, The Johns Hopkins Press, Baltimore, Md.)

In the warfare against the many diseases that are caused by microscopic organisms of one kind or another, it is not always possible to protect ourselves by vaccination or by methods whose objective it is to destroy the germs in their original habitats or breeding places, whether these be in the water, in the soil, or in the bodies of insects and other carriers. It is imperative upon the chemist to see to it that, whenever possible, curative drugs of a very specific nature shall be at our service in all of those instances in which the disease cannot be stamped out by a protective vaccination,

as in the case of smallpox, or by the destruction of the germs at their source, as in the case of malaria and yellow fever. Even in the two last-named instances suppression of the cause of the disease at the source is possible only in the most highly civilized countries. Health authorities tell us that malaria was the largest single cause of death in the southern states before the Civil War while during the World War it was a negligible factor in the death rate of many millions of soldiers. Professor C. C. Baas, who is an authority on the subject, writes as follows in respect to the present incidence of malaria: "The proportion of the people in many countries who have the disease varies from none in some countries to practically 100 per cent in others. Even now millions, yes, more than a hundred million people throughout the world, suffer with it every year and more than a million die."

Since the pharmacist-chemists, Pelletier and Caventou, first isolated quinine from cinchona bark little more than a century ago, this specific alkaloidal remedy against the malarial parasite has been the exemplar for all later efforts to duplicate its action in other infectious diseases. In this field of chemotherapeutic research chemistry has in the past conferred inestimable benefits upon millions of people and promises to be of still greater service in the future. As examples one need name only emetine, destroyer of the *entameba histolytica*, the cause of so-called tropical dysentery although the disease is by no means limited to tropical and subtropical countries; carbon tetrachloride, the most effective synthetic chemical yet discovered for the expulsion of the human hook worm—an anthelmintic with which the field workers of the International Health Board of the Rockefeller Foundation have already cured many million people suffering from the disease; arsphenamine, neoarsphenamine, sulfarsphenamine, tryparsamide and organic compounds containing bismuth, used against that widely disseminated social disease, syphilis, and its congenital manifestations. Some one has said with much truth: "War and syphilis are the two great enemies of mankind." The arsphenamines have also been found to be extremely valuable in the treatment of the tropical disease known as frambesia, or yaws, and one authority goes so far as to say that it seems as though the disease could be completely wiped out by the extensive use of these drugs. Certain organic arsenicals and antimonials and a recently prepared synthetic organic compound of complicated structure (Bayer 205) have a markedly beneficial action in the disease caused by trypanosomes and known as the African sleeping sickness. Chaulmoogra oil is the only product known to medicine as being distinctly beneficial to the unfortunates smitten by the plague of leprosy. It is estimated that there are 16,000 cases of the disease in the Philippines at the present time and of this number only about 6000 are segregated in leper colonies. When lepers are taken in hand in the early stages of the disease it has been

found that a large number of them respond so favorably to repeated injections of chaulmoogra esters that they may later be dismissed from the leper colonies as cured.

Organic chemists have already discovered the true structure of that portion of the chaulmoogra acid molecule that exerts the curative effect and we may confidently look forward to the invention in the near future of synthetic derivatives that will be far more effective against the *Bacillus leprae* than are the chaulmoogra preparations now in use.

Let me not weary you with other instances of more or less successful chemical warfare against our microscopic enemies. Chemists are now engaged all along the battle line, producing ever more efficacious and powerful antiseptics like the flavines, mercurochrome, hexylresorcinol, and compounds such as optochin that may some day be of use in combating pneumonia, septicemias, and other bacterial diseases. Voegtlin has recently characterized chemotherapy as "a hope of mankind."

In this period of the understanding and conquest of the infectious and contagious diseases falls also the great revolution in surgical practice—the era of antiseptic and aseptic operative technic. Today millions of operations are performed yearly throughout the world with avoidance of suppuration with its frequent and often disastrous consequences. In this connection the names of the great Pasteur the chemist, of Koch the physician, and Lister the surgeon, need hardly be mentioned as they are known to all of you. The discovery of the anesthetic properties of chloroform, ether and cocaine, and a multitude of newer agents prepared by chemists must not be forgotten. Without the gift of anesthesia the surgeon with all his aseptic technic could never have developed his branch to its present high state.

IV. Diseases of Non-Bacterial Origin Whose Cause Must Be Referred to the Entrance into the Body of a Harmful Chemical Principle or to the Absence from Our Diet of Specific Dietary Principles Called Vitamins

Thus far we have taken into consideration the extent of the kinship, as it were, between chemistry and our gradually developing knowledge in respect to numerous diseases whose etiology has been referred by medical investigators to microscopic organisms. Chemistry has, however, played an even more important part in the elucidation of a large number of more or less acute and chronic diseases that have in the past levied a heavy toll on mankind and are still doing so in our time. I refer here to maladies whose primary cause cannot be sought in the deleterious action of microorganisms but which must be referred to the presence of some poison of vegetable origin in our food, as seen in the ergot epidemics of the past and in lathyrism, or legume intoxication, still prevalent in India, to name only two instances out of a long list.

These diseases are, generally speaking, of a chronic nature. The chemical principles responsible for them may affect the centers of the nervous system, the vascular system, the liver and other organs, so that permanent contractures and paralysis of the extremities, gangrene, cirrhosis of the liver, and other pathological states arise whose counterparts are seen in certain infectious diseases. Diseases of this class are also of great concern to live-stock growers in all parts of the world. As instances may be named the so-called milk sickness and "trembles" following the ingestion of the richweed (*Eupatorium urticaefolium*), the main poisonous principle of which is now known to be an aromatic oil called trimetol; a disease to which hogs are especially susceptible, due to the consumption of untreated cottonseed meal, the poisonous principle of which has been identified as a crystalline substance known as gossypol; the disease known as Molteno disease in South Africa and Pictou disease in Canada, caused by members of the senecio family which contain a number of deadly alkaloids, two of which, senecifoline and senecifolidine, have been isolated and identified. These are but a few examples out of a long list of diseases induced in both human beings and domestic animals by the ingestion of poisonous principles of vegetable origin. And I cannot here consider or enumerate the equally long list of acute or chronic disorders that are so frequently encountered among our industrial classes, exposed, as they are, to a great variety of deleterious agents of an organic or inorganic nature. Naturally, the chemist has here found an opportunity for the display of his ingenuity and skill in the isolation and characterization of the chemical principles that are responsible for these acute or chronic intoxications.

A second class of diseases of non-bacterial origin, in the elucidation of which the chemists' aid is indispensable, is that enumerated under the headings nutritional disorders, dietary diseases, deficiency diseases, or avitaminoses. These disorders, which in the past have caused the loss of innumerable lives and which even today in either their well-developed or "latent" forms are of the greatest significance, are all due to the lack of essential constituents in our diet—the so-called vitamins. These mysterious and elusive chemical principles, whose true significance was established but yesterday, must always be present in our diet if we ourselves, our children, and the domestic animals are to maintain health. The classical major examples of these deficiency diseases are scurvy, beriberi, pellagra, and rickets. The study of the gradual development of our knowledge in respect to these diseases is a most fascinating one. As long ago as the seventeenth and eighteenth centuries, and even earlier, certain naval surgeons and their commanders had already learned how to guard their sailors on even the longest voyages (three years and more) in the sailing ships of those days against the dreaded scurvy by the free addition of "sweet wort" and sauerkraut to the ordinary ship's diet. Whenever a landing was made

these capable and thoughtful men saw to it also that an abundance of fresh vegetables and such live stock as could be secured were added to the ship's stores. Why this discovery that scurvy is due to a lack of fresh vegetables in the dietary was allowed to lapse and why it remained for our time to rediscover it and harmonize it with more recent experimental findings in relation to other diseases of similar etiology cannot here be considered. The main reason, however, for the slow acceptance of the true etiology of scurvy, irrefutably established by Lind's observations before the middle of the eighteenth century and by Captain James Cook in his second great voyage (1772–1775), during which he sailed 20,000 leagues, a distance nearly three times the equatorial circumference of the globe, without the loss of a man from scurvy, is to be found (1) in the lack until recent times of sufficient knowledge in relation to the chemical composition of foodstuffs and the manner in which they are utilized in our bodies, and (2) in the lack of an experimental method of producing a dietary or deficiency disease in one of the lower animals which would enable experimentalists to evaluate quantitatively the effect of the various elements of our diet either in the way of the prevention or the causation of a deficiency disease. This indispensable experimental method has come into general use only since the eighties of the past century when the Dutch Colonial surgeon and scientist, C. Eijkman, cleared up the true etiology of beriberi, a deficiency disease[1] which has for centuries afflicted the rice-eating nations of the Orient. This investigator fortified his conclusions in respect to the cause of beriberi in human beings by his discovery that when pigeons or chickens are fed for a time on polished rice they soon fall a prey to a serious neuro-muscular disorder bearing a certain likeness to one type of beriberi, and that the diseased birds can be cured in a most spectacular manner by treatment with an extract of rice polishings, in other words, by supplying them with a missing and indispensable constituent of their diet. Since Eijkman's day this experimental method involving the use of animals and even cell cultures has been the great reliance of investigators in their efforts to unravel the mysteries of nutritional disorders, and it goes without saying that a knowledge of chemistry in the widest sense is indispensable in their work.

Let me say but a few words in regard to one only of these dietary diseases, rickets, now well understood as to its causes and one that is happily entirely preventable. It has recently been stated by an authority that from now on no child in the world need have rickets. The hope is justified; nevertheless health officials and physicians still encounter difficulties in

[1] At the time of writing these lines there appears in the *Journal of the American Medical Association*, April 20, **1929**, p. 1325, an article by several Japanese investigators who claim that the disease is due not to the absence of a chemical principle in the diet, but to infection by a specific bacillus.

stamping it out entirely. For centuries this has been the most common nutritional disorder of childhood, especially so among the children of factory operatives and town dwellers of the lower economic level, confined as they are to dark and unsanitary homes. The medical and economic significance of the fact that rickets is due to a lack of a certain vitamin in the food of the child, often coupled with a lack of outdoor air and sunshine, is much greater than can be realized by those who have not concerned themselves with the history of this disease and its complications. The missing vitamin in rickets is a substance of high physiological potency. It has been shown that $^1/_{10,000}$ of a milligram or $^1/_{648,000}$ of a grain of irradiated ergosterol, as the protective agent against rickets is called, will serve to prevent the appearance of the disease in a rat when added daily to a diet that would otherwise inevitably cause it. Naturally, the daily quantity of the principle ultimately derived from plant life that serves to protect a child against rickets is very much larger than that needed for a rat, but it still remains a negligible quantity in comparison with the proteins, fats, carbohydrates, etc., of the food. In this connection it would be in order to give the now-accepted explanation of the beneficial effects of sunlight in preventing the appearance of rickets in children as well as in experimental animals when they are kept on a diet that would otherwise surely lead to the appearance of symptoms of the disease, but to do so would carry us too far afield.

From what has been said it is apparent that we have a new conception in regard to the causation of a number of diseases, or perhaps more truly said, an older conception of disease which modern medical and chemical research has finally succeeded in placing on an irrefutable basis. The mysterious and very potent chemical principles whose absence from the diet of human beings or animals leads to disease and whose number is still being added to, are called vitamins as you have already heard. Students of nutrition and chemists of great ability are now engaged in attempts to isolate them as chemical individuals—an imperative need of the day. How true it is that the discovery of an apparently negligible substance, or the disclosure of a chemical reaction of no apparent or immediate significance, so often causes a revolution in our ideas in regard to the causation and treatment of disease! In these days when we buy our lunch in a drug store and stock the larder with tinned, bottled, and boxed foods, and often pay too little attention to the proper balancing of the numerous organic and inorganic constituents of our diet, we and our children are still in danger of acquiring certain insidious and chronic disorders that may lead to instability of the nervous system, to weakened resistance to infection and to lack of recuperative power and endurance, to say nothing of defective teeth and other evidences of an inferior physical development. Only continued observation and study on the part of clinicians, experts in nutrition, and chemists can guard us against such ever-recurring dangers to health.

A number of the well-known investigators in the field of the vitamins have recently brought forward strong evidence in support of their contention that there is possibly a close relation between a deficient intake of the particular vitamin called "vitamin *A*" and certain inflammatory processes of the genito-urinary, alimentary and respiratory tracts, nasal sinuses and the middle ear. Experiments on rats seem to show that in these animals vitamin *A* is more directly concerned in conferring resistance to such widespread infective and pyogenic conditions than any other known food factor. "While this question is not definitely settled at the moment, it is certainly possible that this relationship exists." "It is generally agreed that a deficient intake of vitamin *A* is a common fault among civilized men. We rely almost entirely on milk, butter, egg yolk, and green vegetables for our supply of this substance, and the consumption of these, especially among the poor, is notably low." (E. Mellanby.)

We cannot as yet foresee or predict in detail all of the possible alterations in our metabolism, with their possibly harmful consequences, that may result from any one of a considerable number of one-sided diets to which some, who are not necessarily food faddists, are restricting themselves. In our latitude, for those who enjoy health and desire to retain it, as far as its retention rests on the quality and quantity of our food, the good old rule based on centuries of experience should hold: good cooking and the proper variety and combination of foods; meats, fats, milk, cream, cheese, vegetables, fruits, and so on through the whole list of edibles. As age comes on it may be well to heed the ancient proverbs cited by Luigi Cornaro (1467–1565): "He that eats little, eats much," and "The food you leave on your plate does you more good than the part you eat."

V. Diseases Whose Causative Factor Lies in the Over or Under Production in Certain Special Organs of Our Bodies of Certain Very Potent Principles—The So-Called Chemical Messengers or Hormones

Now there is still another large group of diseases whose etiology cannot be referred to microörganisms, but which may be classed with the dietary diseases as being of the chemical order, so to speak. Here the causative factor lies either in an under or over production, on the part of certain internal organs, of divers extraordinarily potent substances comparable in many respects to the vitamins. These compounds are indispensable for the development and growth of many structures of our body and for that harmony in the chemical and nervous coöperation of our organs that characterizes the state of health. They are designated by such terms as chemical messengers, or hormones, and are elaborated in certain special and often very minute organs called the ductless or endocrine glands. Of the diseases that are referable in one way or another to these chemical messengers, I may name diabetes mellitus, diabetes insipidus, acromegaly, gigantism,

dystrophia adiposo-genitalis, goiter, and the various forms of cachexia thyreo-priva, Graves' disease or exophthalmic goiter, Addison's disease, grave disorders due to anomalies of the sex glands, and other pathological states due to a more or less contemporaneous alteration in function of several endocrine glands or to a lack of their coöperation in proper sequence. This field of knowledge—that of the endocrine diseases—was first opened up more than 50 years ago by medical and surgical observers, pathologists and physiologists, and since then the general biologist and the chemist have contributed their share toward the solution of its many problems that have already been cleared up, in their main outlines at least. The chemical aspects of these diseases have very naturally given the chemist a unique opportunity for the exercise of his talents. The hormones of the medullary portion of the suprarenal glands and of the thyroid have been isolated as chemical individuals of crystalline character, their chemical constitution has been laid bare and both have been synthesized and can now be made in the chemist's laboratory. The entire list of accepted hormones is now being intensively studied and we may confidently look forward to the day when the last of these vitally important chemical principles will have been compelled to disclose its innermost secrets.

A striking and very recent achievement in this branch of medicine, which again was accomplished only by the combined labors of physicians, physiologists, and chemists, culminating finally in Banting's great discovery, is seen in the success with which the symptoms of diabetes mellitus can now be controlled by every practitioner in the land. All that is necessary is to inject under the skin of the diabetic patient an extract prepared from beef pancreas and containing a minute amount of the chemical messenger called insulin. This extraordinary chemical substance at once alleviates the distressing symptoms and enables one who would otherwise be doomed to a prolonged illness and death to enjoy good health as long as he continues the injections. The beef insulin, injected daily by the patient, takes the place of a deficiency of insulin in the patient's own pancreas.

It may interest you to learn that insulin has now been isolated as a chemical individual in the form of beautiful crystals and that it turns out to be of a protein nature. This appears to be the first instance of the isolation of a specific metabolic hormone in the form of a crystalline protein of a relatively simple composition. An intensive study of the degradation products of the substance with a view to the unraveling of its constitution is now being carried on.

Another and still more recent achievement of medicine of a similar nature and one in which chemists are also coming to the rescue is seen in the control of that very serious and hitherto generally fatal disorder called pernicious anemia. It has been estimated that at any one time there are always

in this country 150,000 cases of this serious disease. Here, as in the cases cited above, experiments of a fundamental character had been made by earlier investigators and the efforts of these pioneers were crowned by Doctors Minot and Murphy of Boston by their discovery that this disease can be cured in most instances by the free addition of calf's liver to the diet. Very recently the chemists associated with these clinicians have succeeded in preparing a concentrated, iron-free liver extract, which is equally curative when taken by mouth in small quantities and so these anemiacs are now spared the ordeal of the daily consumption of excessive amounts of raw or cooked liver. Here again we are supplying a deficiency of a chemical curative substance, which the patient's own liver has not produced in sufficient quantities.

VI. Attempts to Elucidate the Physico-Chemical Mechanism of Life A Great Generalization of Modern Biology—The Chromosome Theory of Heredity

One could continue for hours piling up instance upon instance of modern discoveries in the many branches of medicine in which chemists have worked hand in hand with medical investigators. A similar story could be told of correlated labor on the part of biologists and chemists in the field of general biology. An account of the indebtedness of medicine and biology to physics in the past fifty years must also be omitted here. I should like, however, to pause long enough to remark that physical methods of analysis, such as micropolariscopic, white light, infra-red, ultra-violet, and x-ray analysis, by the use of which the physicist has disclosed the structure of molecules and the architecture of crystals, are now being applied by cytologists in our medical schools and by many biologists to the unraveling of cell structure. Research institutes have been founded in several European capitals and in this country in which these and other methods are being employed with the broad purpose of elucidating "the physico-chemical mechanism of life."

One of the very greatest achievements of biology in recent decades, one which must arouse the admiration of any one with the least spark of enthusiasm in his make-up, is the chromosome theory of heredity. The chromosomes, as seen in the impregnated dividing ovum, are tiny rods made up of a large number of ultramicroscopic, discrete particles called genes which are supposed to be the carriers of our heritable qualities—"the basis of the genealogy of every individual," to quote the words of Professor Thomas H. Morgan, one of the greatest leaders of our day in genetical and biological research. "There are probably thousands of these genes in every chromosome and no two genes appear to be alike. Each individual animal or plant is the product of the activity of all these genes and heredity is the result of the shuffling of these genes in each generation"

(Morgan). These microphysical structures—chromosomes and genes—at a certain stage in the cell division of the fertilized germ cell undergo striking alterations and movements—conjugation, division, and progression into the center of spindle-shaped structures, or asters, which appear in their vicinity and in which the chromosomes finally arrange themselves in a plane perpendicular to the spindle fibers. As cell division proceeds, various chemical and physico-chemical changes take place in these structures as also in the cytoplasm of the cell; the chromosomes react differently to stains, the asters become more rigid in structure, the intervening cytoplasm more liquid in character; alterations of surface tension, viscosity, and electric potential occur.

Now these chemical and physico-chemical sequences—these divisions, movements, and matings of the microphysical constituents of the impregnated germ cell in which our potentialities and destinies lie concealed—are events of a molecular or micellar order whose analysis, in the opinion of competent biologists, waits on the coöperation of the biologist with the organic and the physical chemist and the physicist. The imaginative mind is thrilled in contemplating the possibilities that the future holds in store, once this coöperation shall have become effective.

VII. Cancer

Now, unfortunately, mankind is still plagued by grave maladies whose essential cause is yet unknown and the prevention of which is at present beyond our control. An unconquered scourge that destroys annually great numbers of people throughout the world is cancer which, according to insurance records, is outranked as a cause of death by only two diseases, heart affections and tuberculosis. Like our normal tissues a cancerous growth is composed of microscopic units or cells but, unlike normal cells, those of cancer are outlaws with no respect for limiting boundaries or other people's property, relentless beyond belief, and bent only on multiplying and pushing their earlier colonies ahead of them into healthy neighboring tissues and on continuing this invasion as long as there is any possibility of obtaining nourishment.

The chemical intake and output of cancerous cells—their metabolism, to use the technical term—has been studied by chemists in the case of carcinomatous growths experimentally produced in rats. The work of Warburg and his associates has revealed some remarkable facts in relation to the chemical activities of these cells. They regularly transform vastly greater amounts of the sugar, carried to them by the blood, into lactic acid than it is possible for normal cells to do. Under favorable conditions they can produce in one hour an amount of lactic acid equal to 10 per cent of their own weight. They can thrive and continue to split sugar in nutrient solutions in vitro in which the life-supporting oxygen pressure is re-

duced to the low level of $^1/_{100,000}$ volume per cent; they recover completely even after having been asphyxiated for forty-eight hours. These and other experimenters verified their test-tube findings in regard to the great fermentative capacity of cancer cells in experiments made on the blood passing into and out from a cancerous tumor in the living rat. It will be seen then that the cancer cell differs from the normal cell in that it is endowed with the ability to live at a lower oxygen level and to carry on at a higher level what is called its fermentative capacity. It has very naturally been suggested that, if a method could be found to induce the cancer cell to breathe more deeply, as it were, and to do less fermenting, it would revert more nearly to the type of a normal cell and cease to be a menace. The reverse of this suggestion has been realized by Carrel and his associates and also Fischer who have succeeded in so far transforming the character of normal embryonic cells of the chick by injuring them with arsenic and other poisons, that when they were injected into chickens they gave rise to a malignant growth in these animals—a so-called sarcoma. Now these embryonic cells naturally possess a high fermentative capacity and it may be assumed that the damage done to them by the arsenic and other poisons employed centered mainly on permanently lowering their oxidative capacity, and hence the assumption of malignancy on their part.

Experimenters in more than fifty centers of research are now attacking this broad subject of malignant tumors from many viewpoints, but I cannot here enlarge further on the several avenues of approach toward the solution of the problem. I hold firmly to the belief, however, that this dreaded affliction will eventually come under our control and that we shall see the day when only those will die of cancer who have paid absolutely no attention to mother nature's early warnings. Even at present 60 to 70 per cent of cancers can be completely eradicated by the surgeon when taken in time and when all the conditions are favorable. I am told by surgeons that once the lymph glands are involved only about twenty per cent of the patients can be cured by surgical treatment. The disease generally progresses slowly and hospital statistics show that people afflicted with it live from one to five years after their condition is known to be hopeless. For some unknown reason a very small number of people with the disease, variously estimated as constituting 4 per cent or less of all cancer cases, appear to get well without treatment of any kind. This fact occasionally favors the quack with his preposterous claims. Aside from surgery, radiation is at present the only method that is of value in the treatment of cancer.

Laymen are now being urged to apply to properly qualified physicians at the very earliest appearance of an external growth or of certain persistent symptoms of internal trouble, and not give themselves over to some heartless cancer quack who claims to be the possessor of an infallible remedy of

vegetable origin. The American Society for the Control of Cancer is performing a service of incalculable value in educating the public in these matters. According to the records of the Johns Hopkins Hospital the percentage of the inoperable and hopeless cases of the disease has fallen from more than 50 per cent prior to 1900 to less than 5 per cent since 1920. It is gratifying to learn that patients are now coming to the hospital with growths which are still in their earliest and entirely localized stage and which cannot be diagnosed with certainty as of malignant character by the eye, by the surgeon's touch, or by the use of the x-ray. What is called the chemotherapeutic treatment of cancer, in other words, treatment by chemical substances, is at present in the experimental stage only and the consensus of opinion at the moment is that no permanent and worthwhile success has yet been scored by this method of treatment. In spite of this failure, however, it would be unwise to harbor the fixed belief that never in the future will a method of chemical therapy be discovered that is preventive or curative for cancer in human beings.

At the moment, then, medical science is not in possession of an instrument of precision or of an infallible laboratory test for the diagnosis of cancer in its earliest stages, to say nothing of methods of preventing the disease or of curing it without surgical intervention or radiation when once it has become definitely established.

The pathologist, therefore, is now confronted with the problem of recognizing cancer in its earliest stages or even in the pre-cancerous stage. He is trying to discover the characteristics that differentiate a normal tissue cell from one that is potentially cancerous or from one that has definitely taken on the characteristics of the robber cell. As you can see, here is a problem of the utmost difficulty and of the greatest importance. Among the methods of approach to this problem there is one that is based on the staining of a small piece of living frozen tissue with certain dyestuffs, as, for example, polychrome methylene blue. But now that people with beginning growths are presenting themselves earlier and earlier for examination it has been found that existing methods of staining tissues are inadequate for this earliest differentiation of the cancer cell from one that is not cancerous.

Mr. and Mrs. Garvan, with a keen insight into the nature of this grave problem and a full realization of its importance, have come to the conclusion that more intensive and better coördinated research along this line may possibly yield results of the highest value. Through their influence the Chemical Foundation has financed the work of the Commission on Standardization of Biological Stains. The work of this Commission has been of the greatest importance and of the greatest assistance to the medical and biological research work of the country. Prior to the World War our investigators were entirely dependent upon Germany for the manufacture

of the large number of dyestuffs that are used as biological stains. Today our chemists produce stains of a high degree of purity which have been standardized to meet our own needs and which are being exported to practically every country in the world. With this brief reference to Mr. Garvan's services in supplying the investigators of the country with a large number of dyestuffs so necessary for diagnosis and even treatment, I can return to my account of his interest in the cancer question.

Mr. Garvan has personally made a gift of $60,000, to be expended over a period of five years, to the Johns Hopkins University in support of the work of my colleague, Dr. Joseph C. Bloodgood, who is searching among other things for a differential stain that will more surely enable us to distinguish the cancerous from the non-cancerous cell at the earliest possible moment. Here is where dyestuffs of a new type must be devised and it is hoped that such can be prepared by our chemists in coöperation with Doctor Bloodgood and the Committee on the Standardization of Biological Stains.

I cannot elaborate further on the technical or scientific points that could be taken up in this connection but I may be permitted to give here one paragraph from Mr. Garvan's deed of gift as follows: "My purpose in making this gift is that it will be devoted to the study of cancer, particularly in reference to the use of dyes in its diagnosis and treatment and in the investigation of such problems that arise."

Research work is often a gamble and investigators as a class are more daring gamblers than the stock market has ever known. Win or lose, they remain undiscouraged and, losing, they try again with undiminished hope. In view of Doctor Bloodgood's long experience in his chosen field of work and his many fine contributions toward the surgical pathology of cancer, I venture to prophesy that valuable additions to our knowledge will result from the five years of labor that he and his associates have planned to devote to this subject. A matter of secondary but nevertheless of great importance lies in this that a large number of young investigators will receive a thorough training in the pathological and other methods used in the diagnosis of cancer in its earliest stages. It has been my experience that the most valuable outcome of a bold attempt to solve some difficult problem is the crop of bright and eager young spirits who have assisted an older investigator in his efforts to establish a few new and irrefutable facts.

In this connection, speaking of the various uses of dyestuffs, I may remind you that the Chemical Foundation has also assisted the investigations of Dr. John W. Churchman of the Cornell Medical School in his studies on the uses of aniline dyes in intestinal infections as also the research work of Dr. Hugh H. Young and his colleagues of the Johns Hopkins University on the use of mercuriated dyestuffs in some very serious generalized infections or septicemias. Both of these gentlemen are well known

to the scientific world for their many and important contributions to surgery in their special fields.

VIII. The Common Cold—A Cause for Human Resentment

Unfortunately, mankind is not only still afflicted by grave diseases but is also still harassed by less serious though distressing minor disorders whose significance for the well-being of people has not been properly evaluated. Among these is that very prevalent and distressing, although in itself rarely fatal, infection known as the *common cold*. There is an old saying that a cold in the head lasts a fortnight if you call in a doctor and two weeks if you do not. A friend of mine has remarked that "centuries of human resentment against this malady have finally expressed themselves in action." Mr. and Mrs. Garvan have given concrete force to this resentment and have made it possible for medicine to undertake an investigation into the direct and indirect causes and the possible prevention and cure of this minor plague of all time. Few of us, I think, had realized the very great economic significance of the *common cold* until Mr. Garvan called attention to the statistical evidence in regard to its disabling character. Perhaps only one in ten of our population escapes taking a cold at any winter season. Statistics as to the prevalence of colds among the employees of large industrial concerns, the clerical employees of life insurance companies, the students of schools and colleges and members of a large number of families show that 90 per cent of our people do not escape and that attacks of the *common cold*, and the so-called grippe or influenza, are as high as 1.8 attacks per person per year for the entire population. Put in another way, these and other statistics show that about 40 per cent of enforced absences from duty of several days' duration is due to colds, grippe, bronchitis, and pneumonia. It is safe to assert that the largest amount of this disabling sickness, say 90 per cent and more, is to be referred to the *common cold* as its cause. In parts of the country, as in the middle west, certain corporations have reported that the loss of time from this group of diseases amounts to 3.3 days per person per year. In the four months ending January 31, 1929, there occurred among 181 medical students in the Johns Hopkins University 310 attacks of colds, an average of 1.7 attacks per student. Only 23, or 13 per cent, of this number of otherwise vigorous and healthy young men escaped entirely, 38 of the number were each attacked three times, and 3 actually had five colds in the four months.

But colds are of importance, not only because of the great aggregate of minor illnesses caused by them but also because of their significance in relation to secondary infections of the throat, head sinuses, and bronchi. In the two extremes of life, early infancy and old age, the group of respiratory diseases to which colds belong are among the principal causes of death. In these two classes of individuals an initial *common cold* is espe-

cially likely to lead to a fatal bronchitis or pneumonia. The common cold has usually been regarded by the layman and too often by the physician himself as a disease of too trivial a character to deserve serious attention. For some years clinicians and epidemiologists have known that considerable difficulty is encountered in defining and classifying the varied kinds of so-called colds and in determining the causal relation of a cold to the secondary infections of the throat, head sinuses, and bronchi. Measles and influenza, for example, are in themselves also comparatively mild diseases but their presence predisposes individuals to serious secondary infections and physicians are very generally of the opinion that this is true also of the *common cold* and that there is often a causal relation between the cold and a subsequent pneumonia. At present no sharp clinical distinction can be made between a severe cold and a case of grippe, or between grippe as seen perennially and epidemic influenza. Our lack of knowledge in this entire field of so-called minor infections is indeed deplorable.

In spite of intensive efforts in the past on the part of bacteriologists and epidemiologists to isolate the microörganisms responsible for colds, the grippe, and influenza, the results obtained can only be described as inconclusive. The weight of evidence at the moment is in favor of the view that an as yet unknown ultramicroscopic or filterable virus is the true etiological agent of the *common cold*. Medical opinion also holds an attitude of doubt in respect to the value of certain bacterial vaccines that are now being employed in the hope of preventing the disease or at least mitigating its symptoms. Three well-conducted and well-controlled vaccination studies in relation to the protective and curative value of vaccines in the case of the *common cold* have been made in recent years, two in America and one in England, and the three groups of investigators concerned with these studies agree in the conclusion that the vaccinated groups receive no protection and no benefit as compared with the non-vaccinated groups.

What has been said will give you some idea of the complex character of the apparently simple problem of the *common cold*. Under Mr. Garvan's leadership the Chemical Foundation has made a grant of $210,000 (the expenditure of which is to extend over a period of five years) to the Schools of Medicine and Public Health of the Johns Hopkins University in order that their investigators "may plan and carry out researches into the origin, nature, and possible cure of the common cold." With his usual generosity Mr. Garvan has undertaken to guarantee any and all payments coming under the above-named grant in case the Chemical Foundation should be unable to meet them.

The fund is being administered by a body of investigators whose experience, past training, and special qualifications eminently fit them for this task. It was not feasible to get many projects under way until October 1, 1928, although an earlier start had been made in a clinical study of students.

To give an outline of the committee's plan of attack along various fronts of the battle line, so to speak, would involve wearying you with technical and medical terms, details, and ideas. The comprehensive character of this plan of attack will be better understood when I tell you that it involves the coöperation of specialists in internal medicine, in nose, ear, and throat diseases, bacteriologists, physiologists, pathologists, immunologists, epidemiologists, statisticians, biochemists, specialists in phototherapy, radiology, and therapeutics, not to speak of technicians and secretaries. In addition I may add that there is scarcely a single one of the other branches of medicine and surgery listed in the curriculum of a modern medical school and hospital whose representatives may not be called upon as occasion arises for advice and counsel in this matter of the *common cold* and its complications. As will be seen, then, we have here an investigation that is being carried on in a highly coöperative manner.

I must not forget to mention that Mr. Garvan's knowledge of and interest in these matters is not of recent date. It is known that at his suggestion the Chemical Foundation has for the past several years financed entirely the research work of Dr. A. R. Dochez of the Presbyterian Hospital Laboratories of this city on the causes and possible cure of the common cold. It is gratifying to know that a man of Doctor Dochez's excellent training and one with his fine record of past achievement is also pitting his ability against the common enemy.

Within the past few days he and his collaborators have published a preliminary account of their researches entitled "A Study of Acute Infection of the Respiratory Tract of the Ape" (*Proc. Soc. Exp. Med. Biol.*, April, **1929,** p. 562). These investigators learned by questioning curators of zoölogical collections and importers of the higher apes, that these animals not only frequently suffer from *common colds* but that the source of infection is apparently a human being similarly affected, that the illness bears a striking resemblance to that of human beings and is not infrequently followed by a secondary pneumonia of severe character. A small colony of anthropoids about three years old was collected.

The bacteria of the upper respiratory tract of these apes, during periods of normal health, were found to resemble to a surprising degree those normally present in the human upper respiratory tract. A number of the animals while not under quarantine contracted "colds" (presumably from "chance human contacts"), the symptomatology of which was quite comparable to that seen in human beings—attacks of sneezing, discharge of mucus, followed later by obstruction of the nares, audible breathing, and development of a cough lasting sometimes as long as two weeks. Experiments proved that it is possible to infect quarantined apes that have been free from respiratory symptoms for at least six weeks, by instilling into their nares Berkefeld filtrates of naso-pharyngeal washings taken from hu-

man beings with a *common cold* of at least moderate severity. The incubation period of the disease, thus experimentally produced, in these quarantined animals was 36 hours. Every precaution demanded of a rigid experimentation was taken—"all attendants employing surgical aseptic technic of sterile hood, mask, gown, and rubber gloves. Of the first 7 animals inoculated intra-nasally according to the technic described above, 3 contracted upper respiratory infections similar in their manifestations to the spontaneous infections of the simian and to the *common cold* in human beings. In 2 experiments the symptomatology was ambiguous and in 2 no symptoms developed." For a statement of the findings of these authors in respect to the symptomatology and alteration of the bacterial flora of the upper respiratory tract of the apes studied in the course of the experiments the reader must be referred to their paper. In one experiment, "a healthy chimpanzee, kept in close contact with an experimentally infected animal, contracted, presumably by contact, a spontaneous cold on the fourth day of the experimental infection." Dochez and his associates are of the opinion that the nature of the active filterable agent is as yet unknown.

It would seem that further experimentation with these susceptible anthropoid apes will throw much light on the etiology of the common cold and that methods of prevention and cure could more easily be tried out on them than on human beings. In this connection it should be stated that several observers have during the past 15 years transmitted the disease from man to man by instilling into the nares filtered nasal secretions from persons infected with a cold.

IX. Conclusion

I have given you an outline of Mr. and Mrs. Garvan's generous gifts in support of certain medical and chemical researches and have attempted to elucidate the great significance of these researches for the health of the community. In order to do this I have perhaps wearied you with a recital of certain scientific generalities and details pertaining to the utilization of their gifts but there is another and to me very human and fascinating aspect from which the matter should be viewed. Mr. and Mrs. Garvan have not handed out dollars coupled merely with the injunction "to get to work and show results." Their generosity is based rather on a long and thoughtful study of the medical and chemical questions that affect our welfare in countless ways. They have entered into the thoughts and life-work of the members of the two great professions, medicine and chemistry. They have shown a sympathetic understanding of the ideals, the plans, and the innumerable difficulties that must be surmounted. They have given something more priceless than money—sympathy and understanding of the aims and purposes of scientific investigators, whether these be directed

to the solution of a problem apparently and solely utilitarian or to one that is more abstract and theoretical in character. From a cherished letter written me by Mr. Garvan I quote the following paragraph: "In the enforced inactivity that has come to me through lowered health, my chief solace has been the reflection that out on the firing line unselfish investigators are carrying on the splendid fight of science for humanity—this thought is compensation for much of my own ill health."

Individuals that show qualities of mind and heart of this high order have not acquired them by conscious effort. They are of those fortunate ones at whose first breath there presides a favoring star so that ever after they must "to noble deeds give birth." The rest of us are as God has made us and oftentimes much worse, as Sancho Panza says. We of today are grateful to Mr. and Mrs. Garvan for setting the nation an example of a high standard of generosity motivated by wisdom and inspired by deep sympathy with human beings in their afflictions. And we of today who have been privileged to know them personally hold them in abiding affection and have the highest admiration for their extraordinary personalities—their unusual qualities of mind and heart. May many years of health and happiness be theirs!

The following information concerning the history of the founding of "The American Institute of Chemists' Medal" has been kindly furnished by Dr. M. L. Crossley, a past president of the Institute.

The Institute medal was founded in 1925 as the result of a suggestion by the president in his annual address. The Council provided later that year for the founding of the medal to be known as "The American Institute of Chemists' Medal." The By-Laws of the Institute were amended to include the conditions for the award.

The medalist is selected by the Jury of Medal Award of the American Institute of Chemists, made up of five members each of whom at the time of the award shall be a member of the American Institute of Chemists. The jury consists of the active president of the American Institute of Chemists, the three immediately preceding eligible past presidents of the American Institute of Chemists, and the secretary of the American Institute of Chemists. Each member has but one vote. The senior past president member of the jury is the chairman of the jury. The award is made by majority vote of the jury. The votes are cast by ballot and no votes are allowed to be cast by proxy. The award is made to an individual who, in the opinion of the jury, has rendered noteworthy and outstanding service to the Science of Chemistry and the Profession of Chemistry in America. The award is made at the annual meeting and not more than one medal can be awarded at any such meeting. The Jury of Medal Award meets at the call of the chairman and concludes its consideration during the month of January of each year. The jury reports its selection to the Council and if the report is accepted the medalist selected is notified immediately. One of the conditions required is that the recipient of the medal shall deliver an address upon the subject approved by the Jury of Medal Award at the regular annual meeting of the American Institute of Chemists for that year.

The medal is financed from the Institute's general funds. The first impression was awarded in 1926 to William Blum of the Bureau of Standards; the second in 1927 to Lafayette B. Mendel of Yale. No award was made in 1928. The recipients of the 1929 award were Mr. and Mrs. Francis P. Garvan.

PIONEERS IN PUBLIC SERVICE

JOHN W. DAVIS, 15 BROAD STREET, NEW YORK CITY

For a layman and a lawyer to appear before a meeting of a learned society like this is a proceeding not without peril. If he attempts to discuss even remotely the science to which the members of The American Institute of Chemists are devoted, his presumption is certain to find its due reward in the public exposure of his own ignorance. When he is called on to follow the addresses of Dr. Herty and Dr. Abel the danger in which he stands is doubly magnified. His courage returns, however, with the reflection that the purpose of this meeting is to do honor to a lawyer and a lawyer's wife. Surely a member of the same profession may be permitted to express a vicarious satisfaction at so unusual an event—a satisfaction all the more profound because it is coupled with the sincere conviction that the medal you award tonight is fairly earned and worthily bestowed. The occasions are not many, I fancy, when a body of scientists has gone outside the ranks of science to confer its distinctions; but in this case I feel sure that justice and gratitude alike will vindicate the act.

There are many ways by which men rise to eminence among their fellows. It has always seemed to me, however, that when the Great Assize is held and the roll of the foremost names in history is called, the high places will be held not by the great captains who have caused the very earth to tremble beneath the feet of their marching hosts; not by the statesmen who have raised and ruined states and empires; not by the great philanthropists who have turned their talents and resources to the service of mankind; not even by the writers, poets, musicians, and creative artists who have made the subtle beauty of their dreams the living inspiration and the pleasure of less gifted men. Before all these I think must rank the hosts of the great discoverers who have rolled away the mists of ignorance that blinded human sight. Great explorers and scientists like Archimedes, Copernicus, Galileo, Columbus, Magellan, Newton, Harvey, Watts, Lavoisier, and many more, both known and unknown to fame, will be the first names called; and standing near the head of the line will be the chemist Louis Pasteur, whose labors divided all medical history into two periods, that which preceded and that which followed his discoveries. After all, these are the men who have blazed the trail for the march of human progress. They are the true pioneers; they fight on the eternal frontier that divides the known from the unknown, and as they press it ever backward, humanity moves forward to occupy and to enjoy the new ground they have won. The whole life of the race is bound up in this unending struggle against the slavish limitations of its own vast ignorance. The whole duty of science is expressed by the sentence with which Pasteur opened his essay on Fermentation: "It is characteristic of science," he said, "to reduce incessantly the

number of unexplained phenomena." When the explanations are complete, then truly men shall become as gods.

Whether for lack of opportunity or want of power not all men can be privileged to stand on the firing line in this glorious warfare. We cannot all sail the uncharted seas with Columbus or draw a new map of the heavens with Copernicus, or wring nature's hidden secrets from her with Faraday or Pasteur. Yet since in this war there are no neutrals, it is possible for those behind the lines to have their part in cheering and sustaining the fighting forces. It is for the great service they have been privileged to render in this capacity I take it, that you decorate Mr. and Mrs. Garvan.

The progress of mankind throughout the centuries is marked by the tools he has fashioned for himself. In the dim past archeologists recognize the age of stone, the age of iron, and the age of bronze. In modern history we have seen the age of steam, which brought into being the industrial revolution, and the age of electricity, which has not yet reached its full flower. We are entering now on what I venture to think future historians will describe as the chemical age. The study of matter in its grosser manifestations is yielding to the more intense and fruitful study of matter in its minute and intimate forms. Not only warfare but art, industry, and medicine turn and will turn more and more to the chemists for guidance. Civilization itself can almost be measured in terms of chemical advance. You have decided rightly, I think, that no Americans of this generation have shown a keener appreciation of this truth, and none have rendered more distinct and helpful aid to American chemistry and the chemical industry than have your guests of tonight.

Perhaps I may speak with a measure of familiarity of one of the battles they have fought in this cause. Dr. Herty has given us an account of the Chemical Foundation and of some of the activities in which it has been engaged. It detracts nothing from him or his co-workers to ascribe the major share in its great achievements to the man who conceived it, presided at its birth, guided its early policy and at great cost to himself in both body and spirit defended it against attack until its security and permanence was assured.

It was a shock and a surprise to most Americans to discover during the Great War how completely they were dependent on foreign sources for many of their most important chemical supplies. They learned that some of these touched not only the prosperity but the very health of the nation and of the armies called to its defense. It was an equal shock to discover that across the path of our chemical growth there lay an incredible number of patents, foreign owned and foreign controlled, that served no other purpose than to threaten and prevent development in the United States. The lessons of the War soon taught the observing that America must be sufficient to herself along chemical lines, and that to this end these patents

must be so lodged and so controlled that both the government and the citizen might be thereafter free from their restraint. America took out of the war nothing in the way of material compensation—no reparations, no territory, and no concessions for her commerce or her trade. She did take the right to be mistress in her own house, and she took it by means of the Chemical Foundation. Francis P. Garvan would be the last to claim sole credit for its conception but how large was the part he played will appear from the generous statement by Mr. A. Mitchell Palmer, his predecessor as Alien Property Custodian, who, in his report to the President on the chemical industry, declared:

> The first President of the Chemical Foundation, Inc., will be Francis P. Garvan of the New York Bar, to whose clear vision and indefatigable industry I am chiefly indebted in the working out of this plan.

Yet hardly had the Chemical Foundation entered on its useful work when there was delivered a blow from a quarter whence it might least of all have been expected. This was a suit brought on behalf of the Government of the United States itself to rescind the sale of the German patents and thus destroy the life and utility of the Foundation itself. It was accompanied by reckless charges of illegality and misconduct which affected both the integrity and the honor of all those who had been concerned in creating the Foundation. In the light of facts already in the possession of the governmental authorities it seems incredible that such a suit should ever have been brought or such wanton charges made. They met their just rebuke, for at the end of a trial in which all technicalities of evidence were swept aside and not only the actions but the motives of all those concerned were minutely scrutinized, the course which had been followed in the creation of the Chemical Foundation and the sale to it of the German patents was triumphantly vindicated by the court of first instance, by the Circuit Court of Appeals, and finally by the unanimous opinion of the Supreme Court of the United States. Not only was the entire legality of the transaction affirmed but the unjustified attack upon the honor, integrity, and unselfish purpose of the actors forever repelled. The mental, physical, and emotional strain which such a contest imposes on those engaged in it can hardly be exaggerated. Not the least of the patriotic services rendered by Francis P. Garvan to American chemistry was in his brave and gallant bearing of that burden.

From his testimony in this case, I quote a single paragraph giving his statesmanlike conception of the chief service which the Chemical Foundation was to perform. "We found," he said, "the basis of the German chemical success was its educated public opinion, which found its expression in its support of the development of the industry through schools, through the universities, through the research institutions and government pro-

tection and aid, and through the sustenance of the different industries. We started out to instill such an understanding in this country."

They started to instill such an understanding. Is it too much to say now that such an understanding has been instilled and that the American people know as they have never known before the importance of chemistry to their national life and, knowing, are prepared to support it?

I emphasize again, Mr. Chairman, the pleasure which it gives a lawyer to find honors such as the one you offer tonight falling to a lawyer's lot. It is a double satisfaction that they come in equal measure to the sweet and gracious lady who has so ably seconded all his efforts and collaborated with him to these great ends. Republics are by tradition ungrateful. So devoted are we to the doctrines of equality that except for military service there is little we can do in a public or governmental way to honor private citizens who have served the public welfare. It is only by such societies and in such meetings as this that public gratitude can find its true expression. I congratulate The American Institute of Chemists on the use they have made of this opportunity.

TO MR. AND MRS. FRANCIS PATRICK GARVAN

It is not that you greatly care
For measured words or names of praise,
And brows, I think of laurel bare
Would suit as well your quiet ways.

But they who bid you stand apart
For honor in this crowded hour,
These clanging days of street and mart,
And quest of gathering and power,

Would bring to you their grateful word,
Because the time's exacting need,
Beyond the rest you saw and heard,
Suiting the vision to the deed.

If war and clamor thrust amain,
At frontiers of the varying lands,
You conquer the frontiers of pain
With tenderness and healing hands,

Bringing your aid that one may learn,
That one may do, another know,
That light from out the dark may turn
Upon the road that we must go.

Beyond this noon, this little time,
This brief horizon of today,
This seeking hour, this narrow clime,
In the dim land of far-away,

Some one shall breathe the goodly air,
And some one sing the sunshine through,
And some one shall go loosed from care,
Because of you.

Robert L. Munger

PRESENTATION ADDRESS

JOHN H. FINLEY, THE NEW YORK TIMES, NEW YORK CITY

I have a worn textbook in chemistry, lacking one of its covers, which I used as a student in college. It was printed in 1881. Its author, my professor, was the first person I had ever known who had written a book. To me that printed word was as infallible as the Bible. I, therefore, accepted as an irrefragable and irrefutable fact the statement that the atoms are "very small portions of matter which are supposed to undergo no farther division." My professor, who had once been a pupil of Agassiz, was still a professor when I returned to my Alma Mater as its president and I asked him to represent the college at the dedication of the Kent Chemical Laboratories of the University of Chicago. When he returned, stern and sometimes gruff old Roman though he was, he said with tears in his eyes that he had discovered that he knew nothing about chemistry. The procession had gone by while, without access to the literature of science, he had been giving his days and nights to teaching.

A little later when associated with your President, Dr. Breithut, I read a book called "The New Chemistry," and not only lost most of the chemical knowledge which I acquired as a student but was myself lost in the vastness of the new realm of this science. I remember my first acquaintance with a catalyst described as it was by the analogy of a handful of salt dissolving the island of Manhattan. And I recall, too, the suggestion of our marine origin in the fact that we have in our bodies certain elements (potassium, calcium, magnesium, and sodium) in the same proportion in which they appeared in the water of the pre-Cambrian ocean. But even then the conception of the human body as a chemical laboratory in which the Almighty was carrying forward the evolution of his own image had not come to me—this new version of Paul's figure in which bodies are made a living sacrifice wholly acceptable to God through chemical and spiritual transformation.

But even then the potentiality of the atom had not been realized. The Great Teacher illustrating his doctrines said, "Consider the flowers of the field how they grow." But back of Him a century or more Lucretius, the poet and philosopher, was saying, "Considera opera atomorum," consider the works of the atoms. After two thousand years we are coming to understand their part in the original creation and in the continuing creation in which man is having a part—controlling increasingly his own destiny and having a greater share in the pre-destination of the future life on the planet—even increasing his own stature by taking thought, adding inches if not cubits.

Charles D. Little in his "Handwriting on the Wall," said that the first chapter of chemistry's Book of Genesis is not yet written, which is only

another way of saying that the Creator's Book of Genesis and Revelation has not yet been finished. I found on the galleys one night a bit of verse with these opening lines:

> I think God kept on talking when His Book had gone to press,
> That He continues speaking to the listening sons of men.

But He now carries on with the assistance of His creature man, and notably with that of the scientist and, among scientists, increasingly with the aid of the chemists.

In an unfinished lecture at The Johns Hopkins University by Sidney Lanier on Poetry and Science he tells the Legend of St. Leonor, who with sixty disciples tried to redeem and bring under cultivation a stubborn piece of land in an inhospitable region. So difficult did it prove that the disciples begged the Bishop to abandon the enterprise. *Pater, oramus te ut de loco isto recedas.* But he persisted and one morning a miracle happened: twelve magnificent stags marched proudly out of the forest and stood by the ploughs inviting the yoke. They drew the ploughs by day, retired to the recesses of the forest by night, and appeared again each morning submitting their royal necks to the yoke till after five weeks and three days the work was done. Then the Bishop sowed the wheat and the field became the father of a thousand other wheat fields and of a thousand other homes, with all the amenities and sweetnesses suggested by that word.

"What the stags mean," said the poet, "is that if a man go forth, sure of his mission, fervently loving his fellowmen, working for their benefit; if he adhere to his mission through good and evil report—he will succeed, for the powers of nature will come forth out of the recesses of the universe and offer themselves as draught animals to his plough."

In recognizing the achievements of Mr. and Mrs. Garvan we are but applauding what they have done in coöperation with the Almighty and his eternal forces. The other day some one spoke of a man's doing a certain great work by the grace of God. I suggested, as a Presbyterian, that he change it to the design of God. He was not disposed to do this and perhaps rightly, for we have measurable freedom to make our own future with the aid of these building stones of creation which are now in our chemists' hands. As one who represents the lay public, I give my congratulations and gratitude on their behalf, so far as I may, for what these two associates of the Almighty have done to help mankind on the way to his freer and fuller life.

I have often told of an experience that I had out in the borders of Russia several years ago. Trying to get into that barricaded land, I met at Reval, in Esthonia, a young man who was trying to get out. I asked if he was starving and wished to get to food and the comforts of life. He replied

that he was a teacher in a technological school in Petrograd (a physical chemist) and was wishing to get to Germany for books and apparatus, saying that they in Russia had not known for four years what was going on in the scientific world outside—and adding that he did not know what Dr. Langmuir was doing in Schenectady. It was another kind of starvation. Mr. and Mrs. Garvan, by contrast, have done a great work in bringing word of chemical advance to the doors of hundreds of thousands—that will in time grow to millions.

When Dr. Langmuir was taking luncheon with me some time later, he said, by way of illustrating some theory, that if all the molecules in the glass of water before him were magnified until they were each the size of a fine grain of sand, there would be enough sand to cover the whole United States to a depth of fifty feet, or to cover the State of New York to a depth or height of three thousand feet. If the aureate molecules of this medal were similarly magnified, the whole United States might be overlaid with a slight veneer of gold deep enough to bury even our sky scrapers. That would be as great a disaster as came to Midas, at whose touch everything turned to gold—twigs of trees, stones, sod, apples, bread, and wine—till at last he washed himself in the river Pactolus. But what these two have done will be in its results; in the transforming of bodies into health, the enrichment of fields, the growth of trees, the bringing of nourishment out of the air; the promotion of the general welfare will be as the equivalent in value of the gold which the magnifying of the molecules of this medal would produce.

I have the great honor to present to Mr. and Mrs. Garvan this gold medal of the American Institute of Chemists for outstanding service to the science of chemistry and to the profession of chemists. It bears the motto, "The truth will prevail," and on the reverse the words, "We serve."

He (Francis Patrick Garvan) certainly deserved that medal, for, no matter what may be going to happen now, he held the bridge for twelve and a half years for the American chemical industry against the German dominance which held it before the war. And Mrs. Garvan deserved her medal, for she stood shoulder to shoulder with her husband in his long grueling fight and with him devised the tribute to their little daughter Patricia in the wise benefices to Johns Hopkins. Indeed, there are in works like these more romance, more sheer fun than in all of life's purely artificial amusements.—*New York Evening Post*, May 7, 1929.

Knowledge comes by eyes always open and working hands; and there is no knowledge that is not Power. Do valiantly, and hope confidently, and wait patiently.—JEREMY TAYLOR

ACCEPTANCE ADDRESS*

FRANCIS P. GARVAN, ROSLYN HOUSE, ROSLYN, LONG ISLAND, NEW YORK

MR. CHAIRMAN AND MEMBERS OF THE AMERICAN INSTITUTE OF CHEMISTS: On behalf of Mrs. Garvan and all the Misses Garvan and all the Masters Garvan, and on behalf of myself, I want to thank you for the great honor you have bestowed upon us, and for the many kind expressions in its bestowal. I regret that the doctors forbade me to thank you in person, when they came to realize the depth of my gratitude and of the emotion your kindness has aroused. (A sigh for the days when twelve good men and true were locked in a jury box and, without escape, and for $2.00 a day, provided me with a patient audience.)

We want to thank, also, all the kind friends who have gathered here tonight and assure them that they all deserve, as my friend, Peter Dunne, instantly claimed for himself, the medal for coming. I also wish to congratulate you upon the accuracy of your scientific analysis in determining that the main credit, if any credit there be, belongs to the patience and the courage and the leadership of Mrs. Garvan. But perhaps, above all, credit is due to the Supreme Alchemist who inserted the divine catalyst of love into our union and gave us any power for good which we may have.

It has been a joyous fight. Surely a public man's chest in America may look one day like St. Sebastian's and the next like Nurmi's. I have been unable to get out of my mind tonight the picture of the day I appeared before the Grand Jury in Washington to defend myself against an indictment for the very acts and conduct you seem to view so differently here tonight. Poor Mr. Mellon! He now is going through his St. Sebastian era. Let us all hope that after the heroic service he has given this country for eight long years, in the evening of his life, that he will still live long

* Read by Dr. Breithut.

enough to enjoy the medals of true appreciation and true realization of our obligations and gratitude to him.

I do not want to detain you, but I have just one or two thoughts. One would think, from the addresses of the other gentlemen, that our fight was largely won. I thought so, too. But now it has all got to begin over again next week—next week we will carry that fight to the American people and to the American Congress.

A few days ago a Grecian horse came to town labeled "The American I.G." In it were the same old crowd—Karl Bosch, Ludwigshafen, Leverkusen—the German I.G. who shut off the medicinals and dyes and other necessities from their best customer, the American people, despite the cries of the hospitals and our industries, in order to force us to violate our neutrality. But worse than all, this horse has been brought in here for the purpose of cutting the throat of our chemical independence, our safety in national defense, and the protection of the health of our children and our childrens' children—to destroy the progress we have made since we rejected the threats of the German I.G. under the leadership of Woodrow Wilson in 1915. It has been brought in here by a group of our commission-mad bankers who have taken $30,000,000 out of the funds in their custody, or under their control, to assist the I.G., under the guise of bonds, in the new war to destroy our chemical progress. Always and forever remember the stake for which the Germans strove before the war and in the war and since the war—world power through a monopoly of science.

But enough of this—that battle will be taken up and fought over again, and that Grecian horse will be driven out of the country. American I.G! What an insult to every man, woman, and child in this country! It is a sad thing to find men so money-mad as to be willing to betray their country and their families for just a few more dollars. But enough—this is a pleasant occasion; that battle is for next week.

In the few short years of life the Foundation has left, we hope to continue the series of "Chemistry in Industry," "Chemistry in Agriculture," and "Chemistry in Medicine" with "Chemistry in Electricity," "Chemistry in Forestry," and many others. We hope to raise endowments for our chemical and technical publications, and we hope to start a campaign for funds for chemical educational expansion and pure research in our colleges and universities. But the publication of "Chemistry in Medicine," plus my own illness, has brought to us another realization—we realize that over the centuries all sciences, all professions, and all laymen have dumped the entire battle against disease upon the physician. But we realize now that the battle against disease cannot be handled by the physician alone, for it requires every profession and every layman.

We find that the battle against disease is a battle with a place in the line for every science and every scientist, for every lawyer, for every business

man, for every afflicted person and every healthy person, for every municipality, every state, and every nation.

You have seen from our book the heavy obligations in this battle resung upon the chemist and upon the development of chemistry. We hope to follow this book with a similar book showing the relation of electricity to medicine and the burden resting upon the scientist of that science. We then hope to follow with a book showing the obligations of the lawyer to this battle, and if we can find at last a useful function for my own profession, then indeed we will come back for more medals and more credit. But stop a moment—take the discovery of the mosquito as the criminal in yellow fever. Was it the job of a physician to find that out or the job of a detective? Infantile paralysis came and passed, and there is nothing to show how the germ was carried. When the Foundation gave its money to Johns Hopkins to start a fight against the common cold, which many scientists claim is to blame for sixty per cent of our disease, a year and a half had to be wasted in order to collect the proper evidence or facts surrounding the transmission of the disease. The criminal lawyer or prosecutor, trained for years in proving guilt, excluding every other hypothesis except that of guilt, is a necessary aid to the doctors in all germ diseases. The germs, first, are criminals and it takes a prosecutor's training to help the doctor to find out who the criminal is and how he gets into the human habitat. There are many other ways in which at long last I foresee the bright promise of a lawyer's usefulness.

Business and medicine will be another book. Why should our poor doctors be burdened with the business administration of our hospitals? Why should not our great modern business efficiency be transmitted into this fight against disease? What could we not do in this battle with the help of men like Whitney and Young of the General Electric, Morgan and Cochran of finance, Henry Ford and Sloan, and others too numerous to mention?

Physics and medicine, and so forth and so on—each science we hope to take up in turn and let its greatest proponents assign to their fraternity their positions in the fighting line.

The patient and medicine—why has he been excluded from doing his bit? Why is he not taught to insist that his suffering be not in vain, that the proper history of his case and proper scientific tests be made and recorded, that the sum of human knowledge be at least added to by the light of his suffering?

The duty of the well to the sick—is there a diabetic child in this fair land starving to death because she cannot pay for insulin or a proper diet? Tuberculosis—the disease of poverty, they say. Then comfort and ease, and food, and air will cure it and it is therefore a disease which we have traced to our selfishness and we have found that the cure lies in our

human hearts. In this land of plenty there is no excuse for such diseases.

The living wage is a horrid thing of a past age. So, too, must be the living wage of charity. High wages have made prosperity. Try it with the sick—give them and their families and dependents comfort and food and freedom from care. After all these centuries our great business men, not our economic teachers or colleges, have found out that Jesus Christ was the greatest economist and that the Golden Rule is good business. Perhaps, if we shared with the sick, not gave to them, we might find the Golden Rule a great prescription for their ills, as well as our own distempers. Human disease is the greatest evidence of our inefficiency and our selfishness. Would it not be wonderful if we came to believe that it would be good business to eradicate it? I have only been able to touch the high spots, for these docs have got me on a leash.

What a battle! What a fight! How satisfied and contenting is its lack of limitation! I remember as a boy fighting from 7 o'clock in the morning until noonday on a hillside in a pasture of Silver Lane, East Hartford, with a boy named Janeway Brewer. I think I must have got licked, because I don't remember how it came out. All I remember is rage and tears and joy, and my bare feet in the stony pasture. We sat down and we stood up. We knew no science. We had no audience to goad us on—no audience but the cows we had driven to pasture—and only the dinner bell at the farmhouse was able to end that long, determined fight. And that's the kind of a fight this fight against disease is in which we will seek to enlist all scientists and all citizens, all the wealth and all the power of this great land, and all the beautiful sympathy and gentleness and understanding of your good hearts. And this is the kind of a fight we Irish like—and this is the kind of a fight we pledge you on behalf of ourselves and our children, who are here tonight—Francis Patrick and Flora, Mabel Brady and Anthony Nicholas Brady, Peter Dunne and Marcia Ann—in honor of their sister, Patricia. We line up among the chemists in this battle and we pledge you that our children will carry on long after we are gone. It is the kind of a fight that the Irish like because they like to fight until they wake up dead—and then they don't know whether they are licked or not—the joy of the fighting melts into the merriment of the wake. Great causes are just as intoxicating as night clubs. My beloved wife taught me that. In fact, to be really honest for the first time in my life, I must confess I am a synthetic hero and am, therefore, doubly grateful to your Institute who, upon discovering that my wife was the true synthesist, so kindly, in consideration of my enfeebled condition, included me in this honor.

Give me the man, who instead of always telling you what should be done, goes ahead and does it.—ELBERT HUBBARD

CHARLES MAYER WETHERILL, 1825-1871. PART I

EDGAR FAHS SMITH

Foreword

The accompanying biography of Dr. Charles Mayer Wetherill was the last work from the pen of the late Professor Edgar Fahs Smith. The work was begun in January, 1928, and the manuscript had been prepared in rather full outline but publication was delayed until certain information, necessary for completing the sketch, could be obtained. Professor Smith was awaiting the return from Europe of Dr. Richard B. Wetherill, who had promised to supply various letters and documents concerning his father, when he was stricken by the illness from which he died on the third of May, 1928.

At the request of Mrs. Smith, her husband's manuscript and notes were sent to the writer for such revision as appeared necessary after a perusal of the letters and papers of C. M. Wetherill. This literary material, which was kindly lent by his son, Dr. R. B. Wetherill, is most extensive in character. The collection not only includes diplomas, reports, publications, and other personal papers of C. M. Wetherill but it also contains a large assortment of autograph letters written to Wetherill by many famous contemporary scientists and all of the greatest interest to students of the history of chemistry in America between the years of 1840 and 1870. It was during this great formative period that the chemical destiny of America was being shaped and the life of no chemist illustrates so completely the numerous influences of this era as the many-sided career of Wetherill. The editor, in revising Professor Smith's manuscript, has made extensive use of the papers in Wetherill's letter books, many of which have been selected for publication.

It is to be regretted that Professor Smith did not live long enough to review the wealth of historical material contained in the Wetherill papers in order that they might have been given the sympathetic and kindly interpretation which was the peculiar charm of all his writings. American chemists will be pleased to know that through the generosity of Dr. R. B. Wetherill all the chemical letters, papers, and other documents belonging to his father will find a permanent resting place in the Edgar Fahs Smith Memorial Collection for the History of Chemistry at the University of Pennsylvania.

The revision of Professor Smith's manuscript of the life of Wetherill was undertaken by the writer not only with feelings of the deepest personal obligations to a lamented friend but also from a desire to help toward promoting an interest in the career of the first occupant of the position of Chemist of the U. S. Department of Agriculture—a position to which the editor himself succeeded after an interval of sixty years. The task was performed at odd leisure moments amid the many interruptions of official duties and this is offered as an apology for any imperfections of the work.

The editor would express his great obligations to Dr. Richard B. Wetherill of Lafayette, Indiana, for supplying many facts and illustrations pertaining to the life of his father, and for his criticisms of the manuscript; to Miss Eva V. Armstrong of Philadelphia, former secretary of Professor Smith, for advice in the work of revision; and to Mr. Frederick E. Brasch of the Library of Congress for the loan of several prints that have been used as illustrations.

C. A. Browne

U. S. Department of Agriculture,
December 21, 1928.

CHAPTER I

Ancestry and Education

Among the most prominent of the old Philadelphians who, over a course of several generations of their family histories, have contributed to the advancement of chemistry in America are the Wetherills. They were of old English stock, the founder of the line being a certain Christopher Wetherill who was born in East Riding, England, and, emigrating to America in 1682, settled at Burlington, New Jersey. He afterwards moved to Philadelphia where his descendants became prominently identified with the early history and development of that city. Among these descendants was a grandson, Samuel Wetherill (1736–1816) who became interested in a variety of industrial activities. He was the first extensive manufacturer of cloths in America, the device for his cards and labels, according to an engraved copper plate of the year 1782, representing a lady seated at her spinning wheel, while overhead is the motto "Virtue and Industry Are the Springs of Happiness." Should the inquiring reader desire further details of his business he may turn to an advertisement in the *Pennsylvania Gazette* of April 3, 1782, which reads:

> *Philadelphia Manufacturers*—Suitable for every season of the year, *viz.:* Jeans, Fustians, Everlastings, Coatings, etc., to be sold by the subscriber at his dwelling-house and manufactory in South Alley, etc., etc.
>
> *Samuel Wetherill*

At the time of the Revolution, Samuel Wetherill actively supported the cause of independence and sent clothing gratuitously to Washington's army at Valley Forge where it was most badly needed. He was a prominent member of the Society of Friends, but, having engaged in military service in the defense of Philadelphia and having also taken the oath of allegiance to the United States, he was expelled with other Quakers, who had taken similar action, from the meeting of which he was both member and clerk.[1] These outcasts, having no place for religious worship, united

[1] The following transcript of the record of the meeting at which Samuel Wetherill was expelled has been kindly supplied by Dr. R. B. Wetherill of Lafayette, Indiana:

into a new Society of Free Quakers (called in derision Fighting Quakers) and a Meeting House was erected for their use by public subscription at the corner of Fifth and Arch Streets, the list of subscribers being headed by no less a person than Benjamin Franklin with a donation of one hundred dollars.

The patriot Samuel Wetherill was interested not only in the manufacture of cloths but also in that of drugs and chemicals and it was chiefly upon these last-named products that later in life he concentrated all his business activities. He was the first in the United States to begin the manufacture of white lead, of which the Wetherills became the leading American producers for several generations. During the War of 1812 this firm determined to undersell foreign merchants who, by reducing the selling price of their products in American markets, tried to ruin domestic manufacturers. The Wetherills were successful in their efforts to resist European competition but in 1813 their Philadelphia factory was burned, the destruction being attributed, in the heated feeling of war time, to the secret activities of hostile foreign interests.

A grandson of Samuel Wetherill, named John Price Wetherill (1794–1853), followed in the path trodden by his fathers. At an early age he launched with other members of the family upon an enlargement of the business of white lead and other chemicals which had been established by his grandfather. He was a true scientific manufacturer. He was an organizer and a vice president of the Philadelphia Academy of Natural Sciences, giving aid and attention to science in general.

From an ancestry such as was embodied in the preceding names, to which others might be added, it was quite natural and indeed to be expected that in time there would appear a representative whose earliest inclinations and tastes should be strongly for experimental science, particularly as set forth in chemistry. And this individual finally materialized in the subject of this sketch—Charles Mayer Wetherill (1825–1871)—who was born in Philadelphia on November 4, 1825, the son of Charles Wetherill (brother of John Price Wetherill) and Margaretta Sibilla Mayer, whose ancestry dates back through early German settlers of Pennsylvania to Melchior Mayer (b. 1495), a distinguished citizen of Ulm.[2]

WHEREAS, Samuel Wetherill of this city hath many years made profession of the Truth with us, and we have grounds to hope he hath been convinced of the nature and excellency of Christian union and fellowship, but not being sufficiently attentive to the Divine principle of Gospel peace and love, which leads and preserves the followers of Christ out of contention and discord, has deviated from our ancient Testimony and peaceable principles, by manifesting himself a party in the public commotions prevailing, and taking a test of abjuration and allegiance, and hath also violated the established order of our Dicipline by being concerned in publishing or distributing a book tending to promote dissension and division among Friends: It therefore became our care to labour to convince him of the hurtful tendency of his conduct, but our brotherly concern and endeavors for him not being effectual, he persisting to vindicate his sentiments and proceedings in opposition to the united sense and judgement of Friends, we apprehend ourselves under the necessity, in support of our Christian, peaceable testimony, to declare that he hath separated himself from fellowship with us and become secluded from membership in our religious Society:—Nevertheless, we are sincerely concerned for his welfare and restoration, with desires that by his humble attention to the illumination of Divine Grace he may become so sensible of his deviation and errors as to be rightly restored into membership with us. 8th month, 1779.

[2] Among the papers of Charles M. Wetherill are preserved a family tree of the

Charles and Margaretta Wetherill gave careful direction to the education of their first-born son, who was the eldest of five children. His early education was acquired in several private schools of Philadelphia where attention was given not only to the ordinary courses of instruction but to Latin, Greek, French, Italian, Spanish, and German. The lad was studiously inclined and there is preserved as evidence of this trait, which continued throughout life, an interesting pencil sketch which the father drew in 1837 of his twelve-year old son poring over a large book. At sixteen the youth

Pencil Sketch of Charles M. Wetherill, Drawn by His Father on Thursday, September 23, 1837

Wetherill has written upon the sketch the following note: "My Father drew this picture of me when I was 12 years (and over) old, one evening at Blossom Hill on the Wissahiccon. *Charles M. Wetherill.*"

German and American branches of the Mayer family and an ancient impression of the Mayer coat of arms which was bestowed, according to an ancient record "by Maximilian II, in the year 1570 at the Imperial Diet of Speier, to his Mayers, on account of their merits and campaigns which they have performed not only for him but for the Emperors Charles V and Ferdinand I and for Philip, King of Spain, Royal Imperial Majesties and for the King's Majesty upwards of thirty years both against the Turks and against other enemies of the Empire and of the Austrian House." A particularly gratifying feature of the coat of arms, that has been granted and confirmed, is the Phoenix which has been placed there with allusion to the motto: *Effingit Phoenix Christum reparabilis Ales.*

was far enough advanced in his studies to enter college and accordingly in 1841 he entered the University of Pennsylvania.

A number of documents are preserved that indicate some of the college interests of young Wetherill. Among these is a diploma of his admission in June, 1842, to Junior Membership in the college literary organization, known as the Zelosophic Society, whose emblem consisted of a hand pouring oil into a burning lamp with the motto *Alere Flammam*. In accordance with the classical spirit which prevailed in all our colleges eighty years ago the diploma of this college society is engraved in Latin and begins:

From a daguerreotype

CHARLES M. WETHERILL AS A YOUTH, PROBABLY WHEN A STUDENT AT THE UNIVERSITY OF PENNSYLVANIA

Hoc designat te Carolum M. Wetherill, Societatis Zelosophicae Universitatis Pennsylvaniensis Socium Juniorem esse, causa promovendarum literarum institutae, etc., etc.

Praeses Henricus I. Vandyke
A Secretis Jas. G. Shinn.

Numerous term reports of the Collegiate Department of the University of Pennsylvania bear witness that the scholarship of Wetherill was of the highest character. The last of these reports, dated Dec. 24, 1844, reads as follows:

At the close of the late term Mr. Charles M. Wetherill of the Senior Class was distinguished as First in order of merit in his class with four others equal.

Henry Reed
Secretary of the Faculty of Arts.

At the close of the four years' course the following announcement was made regarding Commencement honors:

University of Pennsylvania
Department of Arts
Commencement Day. 1845
July 3d.

After the public Examination for Degrees held on the 22d, 23d, and 24th of May 1845, the First Honour was conferred on the following members of the Senior Class—

John M. Collins, Henry S. Lowber, Phillip Peltz, Charles M. Wetherill and Samuel Wetherill—equal.

The following speeches in the Commencement Exercises were assigned:

The Greek Salutatory Oration—Charles M. Wetherill
The Valedictory Oration—John M. Collins
from the Minutes of the Faculty of Arts

Henry Reed
Secretary.

The Greek Salutatory Oration which Wetherill delivered on this Commencement occasion is still preserved, neatly written out in Greek script together with the English translation.

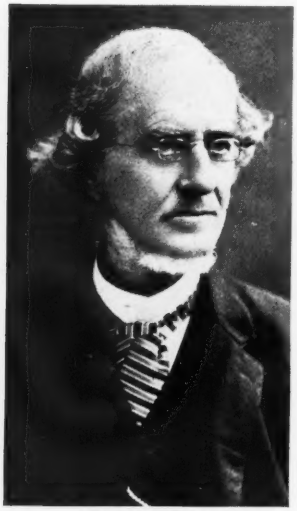
Samuel Wetherill, a son of John Price Wetherill and first cousin of Charles Mayer Wetherill, also won first honors at this commencement and delivered an oration upon "The Age of Augustus." It was this Samuel Wetherill who afterwards invented the furnace process of manufacturing zinc by mixing zinc blende with coal in a furnace whose grate was formed of conical holes which produced a reducing flame through the passage of a draft of air. He also manufactured in 1853 the first zinc oxide that was made in the United States.

A third graduate of the class of 1845, who was to make a name in chemistry and who also obtained a place upon the Commencement program, with an address upon "The Legendary History of Nations," was Samuel George Rosengarten. As a manufacturing chemist he was a member for many years of the celebrated firm of Rosengarten and Company. It is doubtful if any American college or university before 1850 turned out in one year so many graduates who were to win distinction in chemistry as did the University of Pennsylvania in the class of 1845.

And what prompted Charles Wetherill, the student of literature and the classics, directly following his graduation in 1845, to commence the study of practical chemistry in the laboratory of Booth and Boyé? Could the inspiration in this direction have come from his collegiate contacts? There were two occupants of the professorship of natural philosophy and chemistry at the University of Pennsylvania during Wetherill's student years. The first of these was the distinguished scientist Alexander Dallas Bache (1806–1867), a great-grandson of Benjamin Franklin and a cousin of that other distinguished Philadelphia chemist, Franklin Bache (1792–1864). Prof. A. D. Bache taught natural philosophy and chemistry at the University of Pennsylvania from 1828 to 1836, when he resigned his position in order to devote his attention to general educational matters, more especially at Girard College of which he was the organizer and first president. In 1843, during Wetherill's junior year, he returned to his chair of chemistry at the University of Pennsylvania but resigned again the following year to become the Superintendent of the U. S. Coast Survey, an office which he

held until his death in 1867. He was a most devoted friend of Charles Wetherill, in college and also, as we shall see, in later years; it was no doubt more to him than to any other college professor that the young graduate was indebted for his life of chemistry and science. John F. Frazer (1812–1872), who succeeded Bache in 1844 as professor of natural philosophy and chemistry, no doubt did also much toward directing the scientific studies of Wetherill but his influence seems not to have been so marked as was that of his predecessor.

But the motive which influenced young Wetherill to take up practical chemistry was very probably, as in the case of his cousin, an inherited desire, augmented also by the reputation of the Booth and Boyé school which at the time was frequented by many young Philadelphians with scientific propensities and tastes. The instruction given in this establishment, as in that other school of private laboratory instruction directed by Dr. Charles T. Jackson of Boston, was almost wholly in analytical chemistry. Wetherill devoted all his time for a year to study and work in Booth and Boyé's laboratory, where he had excellent opportunities to improve himself in the technic of chemical analysis. One research which he conducted under the collaboration of Dr. Boyé was the "Analysis of a Concretion from a Horse's Stomach," the results of which were communicated by Dr. Boyé to a meeting of the American Philosophical Society (*Proceedings*, Jan. 16, 1846, IV, 230). The concretion consisted largely of magnesium phosphate.



Jubilee Number, J. A. C. S.
JAMES CURTIS BOOTH* (1810–1888).

The year which Wetherill passed in the laboratory of Booth and Boyé was very profitably spent as may be seen from the following letter of certification:

Laboratory at Philadelphia
September 14, 1846

Understanding that our friend and pupil Mr. Charles M. Wetherill is about going to Europe to improve himself in the study of his profession (chemistry), we do hereby certify, as he has desired us, that he has completed his course of study in our laboratory with satisfaction to himself and to us. As Mr. Wetherill is a gentleman of great talents and perseverence, who we hope will sometimes become distinguished in his profession,

* A biographical sketch of J. C. Booth who was President of the American Chemical Society in 1883, 1884, and 1885, was published by Dr. Smith in 1922.—C. A. B.

we would be pleased, if he could meet with kind reception from all professors of chemistry with whom he may come in contact.

Jas. C. Booth and M. H. Boyé,
Professors of Chemistry.

In carrying out the intention expressed in the preceding letter of completing his chemical studies in Europe, Wetherill first went to Paris where he studied in the laboratory of Pelouze. Why this particular choice was made is another matter on which information is lacking. It is possible that Professor Booth, who had at one time studied in Paris, may have had some part in influencing his pupil to make this decision. There is, however, a family tradition that a French chemist, residing at that time in Philadelphia and with whom Prof. J. B. Dumas was corresponding, influenced Wetherill to go first to Paris and seek instruction with Dumas. It is known that Wetherill attended the lectures of Dumas, Gay-Lussac, and Regnault during his Paris residence but his practical work was done chiefly in the laboratory of Pelouze. This was a period in which rising energetic teachers of chemistry at numerous centers in France were very active in its promulgation by laboratory methods. As Pelouze was foremost among these, his activity in directions appealing to Wetherill may have caused the latter to become one of the earliest American pupils of this excellent teacher and investigator, whose work included researches on salicin, on beet sugar, on various organic acids, on oenanthic ether (with Liebig), on the nitro sulfates, on guncotton, and on the composition and manufacture of glass. He also carried out determinations of the atomic weights of several elements and published important works in conjunction with E. Fremy. It was under this teacher then that Wetherill studied analytical chemistry for eight months at the Collége Royal de France during the first semester of 1846–1847, as may be seen from the following:

Theophile Jules Pelouze* (1807–1867).

* Theophile Jules Pelouze, celebrated as an analyst and for his work upon the atomic weights of arsenic, phosphorus, nitrogen, silicon, etc., began his chemical career as a pharmacist. He became preparateur to Gay-Lussac in 1827, was appointed professor of chemistry at Lille in 1830, and elected professor of chemistry in the École Polytechnique and the Collège de France at Paris in 1831.

Certificat d'Étude

Le soussigné Professeur de Chimie au Collége Royal de France certifie que M. Charles M. Wetherill, natif des Etats Unis, a suivi assidument le cours de Chemie analytique pendant le 1er semestre de 1846–1847.

En foi de quoi ie lui ai deliveré le present Certificat. Fait au Collége royal de France, ce 26 Mai 1847.

Ce certifie, en outre, que M. Wetherill a travaillé à mon laboratoire avec le plus grand zèle pendant 8 mois.

Pelouze
Membre de l'Institut.

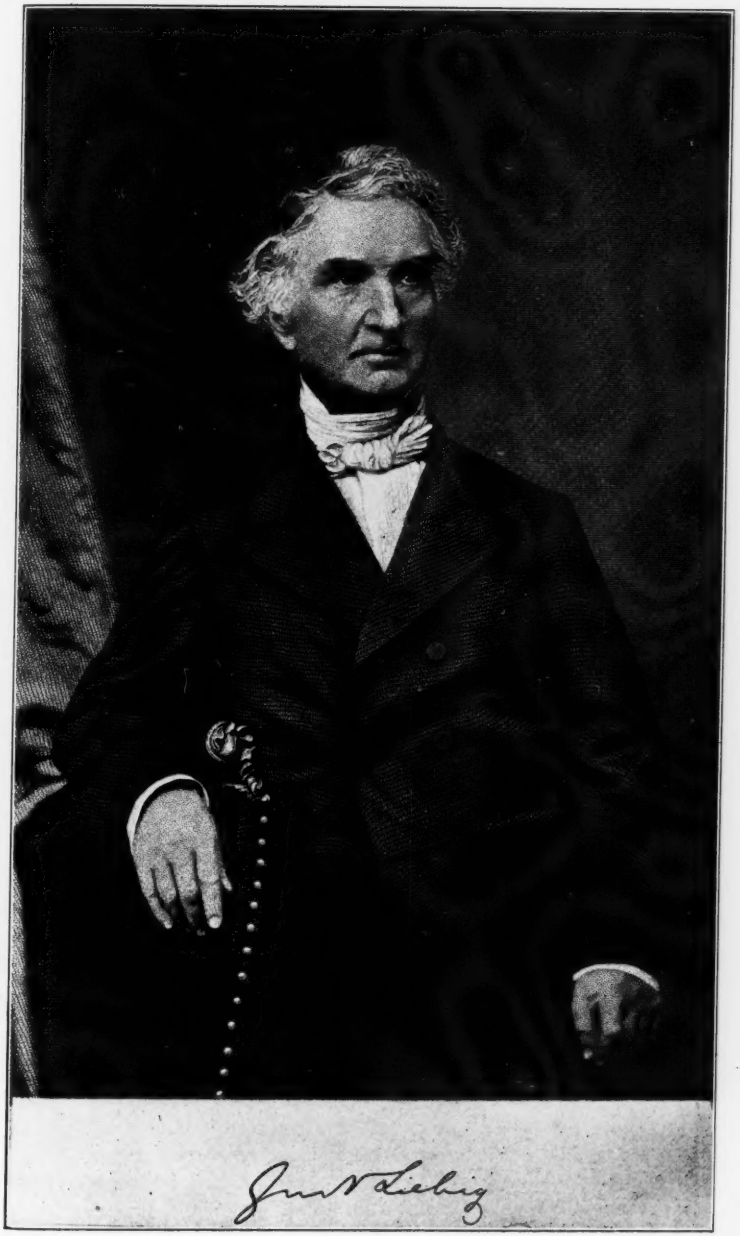
A result of Wetherill's investigations in the laboratory of Pelouze was the publication of his "*Recherches sur la transformation de l'acide tannique en acide galique*," which was published in the *Journal de Pharmacie et de Chemie* [Vol. **12,** 3rd series (1847), p. 197]. The article describes the conversion, by means of sulfuric acid, of tannic acid into gallic acid, with a maximum yield of the latter of 87.4 per cent. The research belonged to a field in which Pelouze was a pioneer and it is interesting to note that Wetherill explained the conversion as a process of hydrolysis.

From a daguerreotype

CHARLES M. WETHERILL IN COURT DRESS WHEN PRESENTED AT THE COURT OF LOUIS PHILIPPE, PARIS 1847.

Having completed his studies at Paris, where he availed himself of an opportunity to be presented at the Court of Louis Philippe, young Wetherill next turned his way toward Germany and it was perhaps under the kind suggestion of Pelouze that in November of 1847 he found himself in Giessen under the world-renowned teachings of Liebig. The Latin diploma of matriculation solemnly announces that after Carolus M. Wetherill, *Philadelphiensis, studiosus chemiae,* had most faithfully promised (*sanctissime promisit*) to obey all the prescribed rules and regulations, he was duly admitted to the University of Giessen on November 6, 1847.

Wetherill remained at Giessen the greater part of two semesters during which he confined his attention almost exclusively to the courses that were given by Liebig. A catalog of the chemical instruction in vogue at this time in Giessen announces that the great master lectured twice a week on


J. v. Liebig

Theoretische Chemie and conducted daily from 9 A.M. to 5 P.M. a *Praktisch-analytischer Cursus in dem chemischen Laboratorium*, while Prof. Dr. Kopp lectured on *Stöchiometrie* and *Allgemeine theoretische Chemie* on Tuesday and Friday from 4 to 5 o'clock, and Dr. Heinrich Will gave a course to pharmacists in analytical and general chemistry. Chemists will be grateful for this peep into the instructional opportunities that were placed at Wetherill's disposal. From our present viewpoint it looks like a meager provision considering the stupendous results which emanated from that attractive center.

(*From a daguerreotype*)
CHARLES M. WETHERILL IN COSTUME OF A GIESSEN UNIVERSITY CORPS STUDENT, 1848

While Wetherill perhaps may have heard an occasional lecture by Professors Kopp and Will, no courses except the two given by Liebig are mentioned as having been attended by him in the official register of the University. In Wetherill's *Abgangs-Zeugniss* (certificate of leave) which was given under the date of May 24, 1848, we read for the winter semester 1847–1848 the following comments written in Liebig's own hand:

Ordnungs Nr.	Angabe der Vorlesungen	Namen der Lehrer von welchen die Vorlesungen gehalten worden sind	Zeugnisse der Lehrer über den Besuch der Vorlesungen
1.	*Praktisch-analytischer Cursus im chemischen Laboratorium*	*Herr Prof. Dr. von Liebig*	*Mit dem grössten Fleiss und Eifer*
2.	*Allgemeine theoretische Chemie*	*Herr Prof. Dr. von Liebig*	*Mit ausgezeichnetem Fleiss*

This brief evidence of Wetherill's "remarkable industry and enthusiasm," written by his teacher Liebig, still carries the weight of authority although eighty years have passed.

One wishes that some account of the life and contacts of Wetherill at this time could be found, for much interest surely accompanies them. In due course, however, the period of training came to an end, the examinations usually dreaded were things of the past, and from a copy of the coveted doctor's diploma one learns that the latter was awarded:

Viro nobilissimo atque doctissimo
Carolo Mayer Wetherill
Philadelpheno
Post probatas in Examine rigoroso cum laude peracto eximias
ingenii et doctrinae dotes
Summos Doctoris Philosophiae Artiumque Liberalium
Magistri Honores
Etc., Etc.
May 30, 1848.

The young doctor was at liberty to rejoice and enjoy the congratulations of friends on his successful career. Possibly, too, he took pride in the

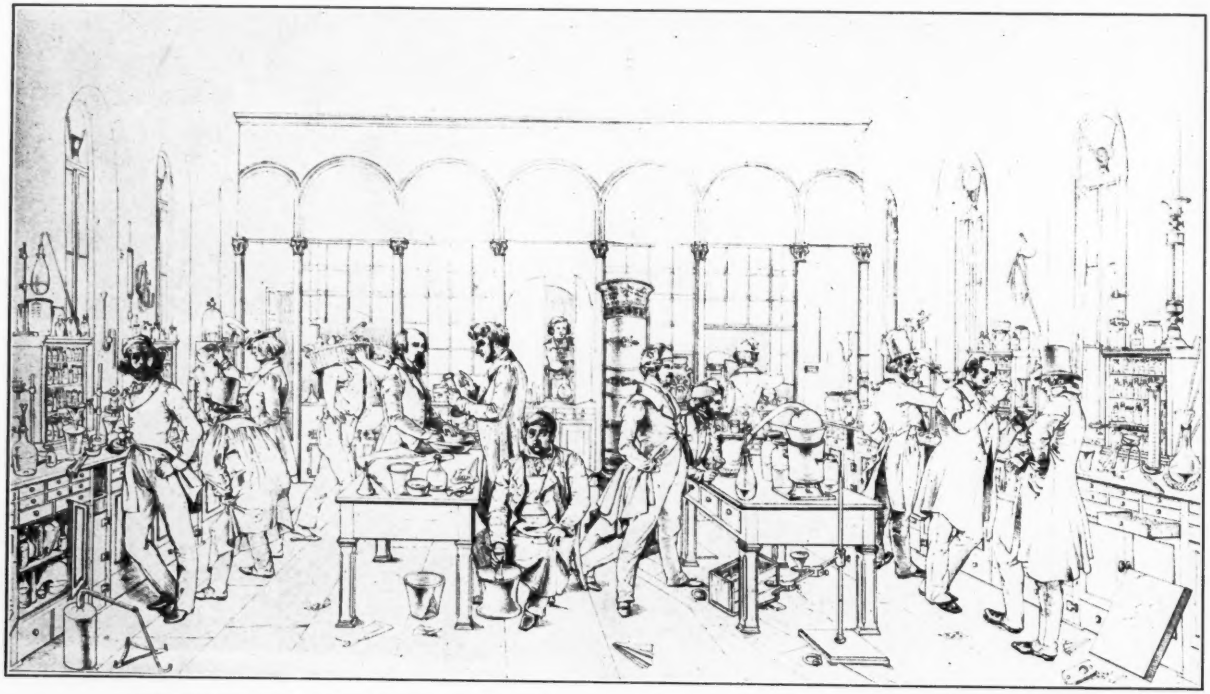
(*From an old wood cut*)

EXTERIOR VIEW OF LIEBIG'S LABORATORY AT GIESSEN, WHERE C. M. WETHERILL WORKED IN 1847 AND 1848

printed form of his inaugural thesis entitled *Über Schwelfelsaures Aethyloxyd und dessen Zersetzungsproducte mit Wasser* which appeared in the *Annalen der Chemie und Pharmacie*, Bd. 66, 117 (1848). It was an interesting research at the conclusion of which appear these words:

Vorstehende Versuche habe ich unter der Leitung des Herr Prof. Liebig's Ausgeführt.

Indeed, Wetherill was the first person to isolate this neutral ethyl sulfate, and to execute such a thorough examination of its decomposition products. Chemists will read the contribution with pleasure. They will note the



Interior View of Liebig's Laboratory at Giessen, from a Drawing by Trautschold Made in 1842*

* See footnote on page facing this illustration.

splendid care taken by Wetherill in the execution of the study. Of course most of the work was upon organic bodies. Their conversion into carbon dioxide and water through the instrumentality of cupric oxide and lead chromate arrests a degree of thought. A second investigation was made by Wetherill at this time, which may have constituted a portion of his thesis, as it was instituted at the instance of Liebig. It appeared in the *Ann. d. Chem. und Pharmacie*, **66**, 150 (1848) and was devoted largely to the analysis of *Quinine hyposulfite*.

Young Wetherill had now completed his European studies; the two years which he had spent abroad in the best chemical laboratories of France and Germany had not only greatly enlarged his scientific knowledge and experience but they had also been immensely valuable in helping him to establish lifelong friendships with other young Americans, such as R. Ogden Doremus and Wolcott Gibbs, who at this same time were adding the finishing touch to their chemical education by a course of studies in Europe.

* A description of the illustration opposite with key is contained in an article by Friedrich Schödler in Westermann's *Jahrbuch der Illustrirten Deutschen Monatschefte*, Vol. **38** (1875), pages 21 to 47. There is a tradition in the Wetherill family, based no doubt upon the strong resemblance in features, that the figure sitting on the end of the table with hands resting on a large evaporating dish is Charles M. Wetherill and that the figure standing opposite to him and holding a cylinder is Liebig. This supposition seems, however, to be incorrect as Trautschold's sketch, according to Schödler, was drawn in 1842 and Wetherill did not go to Giessen until 1847. According to Schödler the figure with hands on the evaporating dish is Wilhelm Keller, who afterwards became a practicing physician in Philadelphia, while the figure standing opposite is Dr. Heinrich Will.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Junior Pharmacologist. Applications for junior pharmacologist must be on file with the Civil-Service Commission at Washington, D. C., not later than June 25th. The entrance salary is $2200 a year. Higher salaried positions are filled through promotion.

The examination is to fill a vacancy in the Hygienic Laboratory, U. S. Public Health Service, Washington, D. C., and vacancies occurring in positions requiring similar qualifications.

The duties are to assist in the study of pharmacological action of drugs, and to act as a research assistant in pharmacology; to conduct bioassays upon U. S. P. drugs and glandular products; and to assist in the development of bioassay methods for various drugs.

Competitors will be rated on chemistry, pharmacy, physiology, pharmacology, and a thesis handed to the examiner on the day of the examination.

Full information may be obtained from the United States Civil-Service Commission at Washington, D. C., or from the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

BIOPHYSICAL CHEMISTRY.* PART II

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Colloid Dynamics

Certain sciences, like organic chemistry, make extensive use of pictures, while others, *e. g.*, mathematics, are built almost entirely of abstract concepts. The organic chemist's "formula" is an entirely different thing from the formula of the mathematician. Most of those who are not mathematicians prefer picture-hypotheses to algebraic formulas.

In a previous paper[21] it was shown how the structure-hypothesis of molecular orientation brings together many of the properties of biocolloids. The methods of thermodynamics, which are independent of structural hypotheses, can also yield valuable information. Earlier attempts made in this direction did not lead to advances comparable with those obtained in other branches of physical chemistry because the chief thermodynamic factors, temperature, pressure (gas or osmotic), and volume are not suitable variables for colloid systems. Colloids have little or no osmotic pressure, their change with temperature is erratic, and the volume factor is not so important as the surface. By the substitution of *swelling pressure* in place of osmotic pressure; by using the *volume of the surface layer* in place of volume; and by the introduction of a *colloid potential* which is to colloids what temperature is to gases and solutions, one can apply the reasoning used in thermodynamics with striking results.[22]

As an example, a colloid engine can be constructed which transforms chemical energy into mechanical work at constant temperature. The apparatus used by Langmuir[23] for surface films will serve to demonstrate the principle of the colloid engine. (Figure 12.)

A shallow tray filled with water acidified with hydrochloric acid has a fixed barrier (paraffined copper plate or rod) A and a movable aluminum "float" B. A monomolecular film of oleic acid, lying on the acidified water between A and B exerts a pressure on the float B, which pressure can be measured by placing weights on the balance at C. If the concentration of oleic is one molecule per 40×10^{-16} cm.^{2} it exerts a pressure of about 17 dynes/cm. on the float B. On adding carefully a drop of alkali to the film, or bringing over it some ammonia gas, the oleic acid is changed into soap and the pH (or —log H-ion concentration) of the surface rises from 1.3 to 9.5, approximately. At the same time the pressure increases from 17 dynes/cm. to 44 dynes/cm. which is the surface tension lowering due to a saturated film of soap. This, of course, is only a momentary change, because the soap formed soon reacts with the acid in the interior of the liquid and the film returns to its original state.

* Based on a series of five lectures delivered at the second Institute of Chemistry, Northwestern University, August, 1928.

[21] THIS JOURNAL, **6**, 858–67 (May, 1929).

[22] "Colloid Dynamics," *Chem. Rev.*, **4**, 1 (1927).

[23] Langmuir, I., *J. Am. Chem. Soc.*, **39**, 1879 (1917).

The system shown in Figure 12 can, therefore, be made to work as an engine, the strip of aluminum *B* being the movable piston. With every increase in pH (addition of alkali) the pressure of the film increases and the piston *B* is moved outward. On removing the source of alkalinity the pH falls and the piston resumes its former position.

It must be mentioned that excess of acid (below pH 4) also causes an increase in surface pressure; the pH cannot, therefore, be accepted as an absolute measure of the "colloid potential" any more than the expansion of mercury or alcohol can be relied upon to give the correct temperature under all conditions.

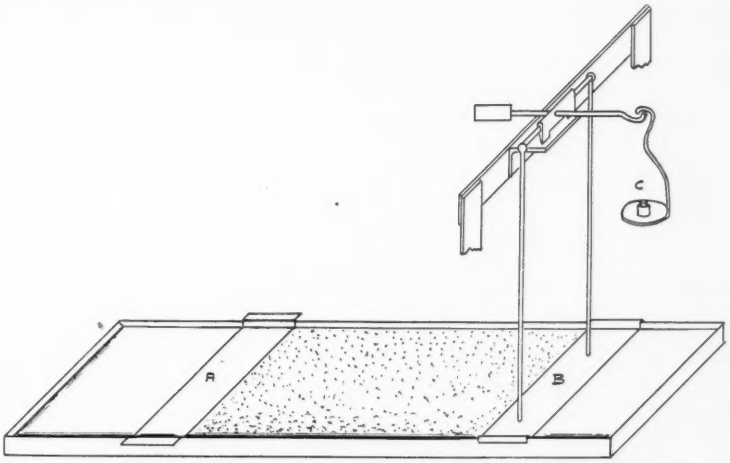


FIGURE 12.—SURFACE PRESSURE APPARATUS

This "chemical engine" exemplifies the principle of direct conversion of chemical energy into mechanical work.

The behavior of soap films is reproduced by gelatin and proteins in bulk. They possess a minimum swelling power at a certain pH and tend to absorb more water when either acid or alkali is added to them.[24]

The Muscle as a Chemical Engine

It has long been a puzzle how the muscle works; physiologists have learned that the source of energy is obtained from the change of glycogen (a sugar-like substance) to lactic acid and the neutralization of the acid by the phosphate "buffer" of the blood. Part of the lactic acid is then

[24] Loeb, J., "Proteins and the Theory of Colloidal Behavior," McGraw-Hill Book Co., New York City, **1922,** p. 71; Fischer, M. H., and M. O. Hooker, *J. Am. Chem. Soc.*, **40,** 273 (1918).

burned to CO_2 and the remainder reconverted to glycogen. However, as Hardy[25] remarks: "A biologist today is pretty much where an engineer would be if he knew even in detail the cycle of chemical changes which took place within an internal combustion engine, but was wholly ignorant of the disposition of the moving parts."

The knowledge that a surface film or gel will expand and contract *reversibly* under the influence of physico-chemical agents brings us one step nearer to a fuller understanding of the way in which the muscle works. The next step is to determine what causes the expansion and contraction of the muscle. Gorter and Grendel[26] have shown that a thin film of muscle protein floating on water contracts when acid and expands when alkaline, but the indications are that the pH changes in the muscle itself are not sufficiently great to account for its contraction and relaxation. Moreover, only a small portion of the energy is obtained from pH changes (neutralization of lactic acid); the greater part is obtained from oxidation processes (changes in rH), and it seems probable that the extension and contraction of the muscle is connected with this change. In general, that factor which causes a colloid to expand may be called the "colloid temperature" or potential, by analogy with the temperature effects in gases and liquids.

The Meaning of pH and rH: The Colloid Potential

pH and rH are chemical potentials. The word potential means "work producer." Wherever there is a difference in some kind of potential, one has energy available and may employ it to do work. The potential difference may be a difference in electrical potential which will give electrical energy; it may be a difference in heat potential (temperature) which will yield heat energy; or it may be a difference in pH or rH in which case its equalization gives rise to the energy liberated during chemical or physico-chemical reactions.

In the steam engine *temperature* is the potential: heat flows from a higher to a lower temperature and in doing so it is harnessed to useful work. In the living organism pH and rH are the chief "work-producers." Let us consider rH first. Electrons flow from a higher rH to a lower rH just as heat flows from a body at higher to one at lower temperature. A body which has an excess of electrons is called a reducing body (chemically "hot"). One which takes up electrons with avidity is called an oxidizing body—because oxygen is typical of such bodies. Each oxygen atom is two electrons short of a stable configuration. It is chemically "cool." On the other hand, sodium atoms are chemically "hot" or reducing be-

[25] Hardy, Wm., "Colloid Symposium Monograph," Chemical Catalog Co., New York City, **1928,** Vol. VI, p. 7.

[26] Gorter, E., and F. Grendel, *Nature* (London), **117,** 552 (1926).

cause each of its atoms has one electron more than is needed for a stable configuration.

The energy needed for our daily work is obtained mainly from the oxidation of carbon and hydrogen which are two of the main constituents of organic bodies. They have in their atoms electrons in excess of a stable arrangement and under suitable conditions these electrons can be given over to, or shared with, oxygen. At the same time the oxygen which takes up electrons becomes attached to the carbon or hydrogen with the formation of carbon dioxide and water, respectively. The atom which loses electrons and becomes chemically "cooler" is said to be oxidized. The atom which gains electrons is said to be reduced.

Reduction-oxidation, therefore, is the process of transference of electrons from one atom or molecule to another, and this fall of the electron, from a higher rH level to a lower rH level, supplies the energy needed by the living organism—just as water falling from a higher to a lower level supplies hydrodynamic energy, and heat flowing from a hotter to a cooler body supplies heat energy.

Alkalinity-acidity (pH) can be measured in the same way as oxidation-reduction (rH). From two solutions at different pH an electric current may be obtained. Here we have a transfer of ions (electrically charged atoms, H^+ and OH^-) in place of electrons. pH is expressed in terms of the concentration of hydrogen ions since it is assumed that it is the difference in their relative concentration that gives rise to the electrical potential difference. Both pH and rH can be, and often are, determined in a simpler fashion by means of the color change in indicators such as litmus.

Differences in pH and rH, as we have seen, are work-producers. They can generate an electric current or can move a piston or bring about the contraction and expansion of a muscle. Other ions besides H^+ and OH^- can produce these effects and can therefore influence the "colloid potential," but at present our methods of measuring and expressing the effects due to salt ions are very imperfect.

The Importance of pH and rH in Biology

Biocolloids are very susceptible to changes in pH and rH. It is well known that certain plants will grow only in an acid substratum like that produced in marshy ground by decomposing sphagnum moss while other plants prefer an alkaline soil rich in lime.[27] The influence of pH on cardiac tissue, ciliary movement, metabolism of the developing egg, and a variety of other biological processes has been described in the literature.[28]

[27] Wherry, E. T., *Proc. Acad. Natural Sci. Phila.*, **1920,** p. 113; *Ecology,* **4,** 395 (1923).

[28] Clark, W. M., "The Determination of Hydrogen Ions," Williams and Wilkins Co., Baltimore, Md., 3rd ed., **1928,** p. 580.

Fischer[29] ascribes the excessive water content of certain organs in nephritis and edema to increased acidity of the tissues. Schade[30] illustrates convincingly the effect of pH on the swelling of connective tissue.

Oxidation-reduction investigations are somewhat more difficult to carry out, and we know as yet relatively little about the influence of the rH potential on various organs or of its intensity in the interior of cells.[31]

Warburg has shown[32] that in the cancer cell* the lactic acid which is formed from the breakdown of the glycogen, is not oxidized completely to CO_2. Although the blood supply is apparently normal the cancer cell behaves in the way in which normal growing cells would behave *in the absence of oxygen*. In other words, its oxidation capacity, its rH potential seems to have been changed; one may compare it to an overheated engine.

Further, Reding, McDonald, and others[33] have concluded that cancer patients have a higher blood alkalinity than normal (average pH 7.48 instead of 7.38).+

Spontaneous Dispersion

Returning to simpler conditions, it is interesting to note that a change in pH can produce spontaneous disintegration of oil drops. A phenomenon which has long puzzled scientific observers is that when a little oil (containing some free fatty acid) is placed in contact with an alkaline water solution, the oil becomes emulsified in the water. This receives a simple explanation in terms of the newer knowledge of surface behavior. The free fatty acid present in the oil accumulates (is adsorbed) at the oil-water surface and, as we have seen in the Langmuir experiment, exerts an appreciable pressure. When the oil comes in contact with the alkali this pressure increases considerably and actually becomes greater than the surface tension, which leads to the spontaneous break-up of the surface. (Figure 13.) The analogy to a liquid which boils when vapor pressure becomes greater than the outside pressure is obvious: the surface tension repre-

[29] Fischer, M. H., *Kolloidchem. Beihefte*, **9**, 191 (1917).

[30] Schade, J., Alexander's "Colloid Chemistry," Chemical Catalog Co., New York City, **1928**, Vol. II, p. 638.

[31] Seifriz, Wm., *Ibid.*, p. 405.

[32] Warburg, O., *Klin. Wochschr.*, **4**, 12 (1925).

[33] Reding, R., "L'equilibre acide-base et l'equilibre ionique dans le cancer," Liege, **1926**; McDonald, E., *Science*, **69**, 177 (1929).

* The cancer cell is very much like a young growing cell, but instead of coming to maturity and taking up a useful function in the body, it multiplies indefinitely to the detriment of surrounding tissue.

+ The presence of excess of monovalent cations (Na^+, K^+) over divalent (Ca^{++}, Mg^{++}) has also been pointed out as an important factor leading to increased conductivity and permeability of the cell membrane. Such increased permeability, it is contended, favors cell growth and division.

sents the external (atmospheric) pressure; the surface (or interface) is equivalent to the volume occupied by the vapor, and the pressure of the molecules adsorbed at the surface represents vapor pressure.

If the oil with fatty acid is sufficiently viscous and the alkaline solution is of the right concentration the oil droplets assume various life-like shapes (amoeboid movements). In an article by Herrera[34] are reproduced some striking photographs of peculiar forms taken up by oil drops under the influence of surface forces.

Are Colloids Amorphous?

Little has been done toward a systematic investigation of colloid forms, although such investigation promises to be of great value. Crystals were studied and classified long ago; colloids were assumed to be amorphous and the beautiful symmetry of living matter, of leaves and flowers, was ascribed to some mystic vital influence.

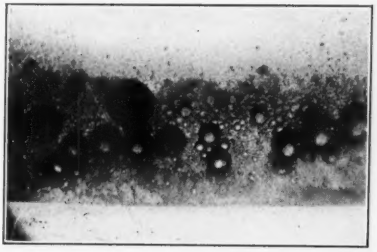


FIGURE 13.—SPONTANEOUS DISPERSION OF ONE LIQUID (WATER) INTO ANOTHER (NITROBENZENE CONTAINING 10% FERRIC CHLORIDE)

Magnification 50 diameters. The smaller globules near the interface between the liquids are in violent motion and appear blurred (exposure $^1/_{40}$th second).

A careful consideration will show that the shape of colloids is not entirely haphazard. One seldom finds in colloids the regular straight lines and angles so conspicuous in crystals; but the curved lines and surfaces which are typically colloid boundaries frequently demonstrate a remarkable degree of symmetry. The photographs reproduced in Figures 14 and 15, representing cracks in a synthetic urea-formaldehyde "glass" are examples of remarkable periodicity and striking resemblance to flower buds and other organic structures. Other investigators[35] have been able to reproduce by means of colloid precipitates many of the forms found in the living kingdom. The regularity of these forms suggests that they depend on definite laws as crystal forms do. The orientation of molecules which has been demonstrated in many colloids in different ways (x-ray pictures, optical behavior) points in the same direction. The study of colloid forms, of the laws that regulate the growth of a bud or the shape of a rose, offers a wide field for the researcher of the future.

[34] Herrera, A. L., Alexander's "Colloid Chemistry," Chemical Catalog Co., New York City, **1928,** Vol. II, p. 81.

[35] Leduc, St., *Ibid.*, p. 59; Fischer, M. H., and M. O. Hooker, *Kolloid Z.*, **19,** 220 (1916); Kopacewski, W., "L'état colloidal et l'industrie," Paris, **1927,** p. 282.

FIGURES 14 AND 15.—COLLOID FORMS

Cracks in synthetic glass (urea-formaldehyde resin); magnification 50 diameters.

Periodicity in Space and in Time

Closely connected with the question of form is the consideration of periodic precipitates (Liesegang's rings) in gels and in porous substances. Numerous views have been advanced to explain these peculiar phenomena, but they still await a wholly satisfactory interpretation.

Time periodicities like the pulsating decomposition of H_2O_2 and the recurrent liberation of hydrogen by certain metals in acids, have a great significance in biology. They, too, are related to surface phenomena. Thus R. S. Lillie[36] states: "The periodic or rhythmical reactions of inorganic chemistry are surface reactions characteristic of polyphasic systems of a somewhat special type;" and again, Hedges and Myers[37] remark: "This property (periodicity) is associated with surface and is probably a function of surface energy." These authors suggest that rhythmical physiological phenomena, like the heart beat, will be found to be caused by a progressive increase in the concentration of some substance at an active surface in the organism.

Catalysis and Life

The slowing or quickening of chemical or physico-chemical reactions which constitute periodicity also fall within the mysterious realm of catalysis. Much remains to be done toward an explanation of the mechanism of catalysis, but here again many authorities ascribe great importance to the *surface region* as the seat of catalytic forces. In the *6th Report of the Committee on Contact Catalysis* it is stated that "Contact catalysis does not take place unless one or more of the reactants is adsorbed on the surface of the catalyst."[38]

The action of enzymes, hormones, viruses, and other constituents of living matter is most conveniently described at present in terms of catalytic action. Consider the following simple comparison of a living and non-living system: one vessel contains a sugar solution and some live yeast cells—another has the same sugar solution with yeast cells that have been killed by heating. In both cases the change of sugar to alcohol will be accelerated, but at different rates.[39] The dead yeast cells differ from the live cells in one important respect, the life factor, and this is reflected and can be measured in terms of the *changes in the rate* of the reaction, and of reproduction. By stipulating a type of catalyst that reproduces itself, one could theoretically construct a system which would have the

[36] Lillie, R. S., *Science*, **67,** 583 (1928).

[37] Hedges, E. S., and J. E. Myers, "The Problem of Physicochemical Periodicity," E. Arnold, London, **1926,** p. 15.

[38] Burk, R. E., *J. Phys. Chem.*, **32,** 1602 (1928).

[39] Rubner, cf. Arrhenius' "Quantitative Laws in Biological Chemistry," G. Bell & Sons, London, **1915,** p. 61.

essential properties of living matter, namely, growth and reproduction under favorable conditions.[40]

The indications are that a fuller understanding of life processes depends greatly upon a deeper insight into the laws of catalytic action. Strictly speaking, one cannot explain anything, however simple. There is always a "why" beyond the "why" we have answered. Most scientists are satisfied that they understand a thing or a happening when they can measure it and know how to influence it or bring it about. It seems particularly desirable that an absolute measure should be agreed upon, so that catalysis in different systems can be measured and compared.

Catalysis may be expressed conveniently in terms of distribution of events in time, the events being measured by the change in entropy. "Living forces" and catalysis therefore can influence the distribution of entropy in time.

In our everyday method of distinguishing between animate and inanimate matter we constantly make use of this basic property. An animal has a certain amount of energy (obtainable from chemical and physical changes) stored in its body. If the animal is dead, one can foretell roughly what will happen to it. Hence, the events have a relatively definite position in time. Not so if the animal is alive. Life may be said to influence the distribution of events, although the total increase in entropy is apparently unaffected by the presence of life. The displacement of events, not predictable from our present laws, is ascribed to a "life force." Naturally, in the last analysis, this life force is an arbitrary concept just as Newtonian force is. When a body is accelerated in space a Newtonian force is assumed (or at least it was, until the advent of generalized relativity); when an event is accelerated in time a living (or catalytic) force is said to be present.

Summary

In a young science such as biophysical chemistry there is room for considerable divergence of opinion in the interpretation or arrangement of facts. The interested reader who will consult some of the articles and books mentioned in this paper will find other points of view. In our treatment of the subject two ideas have served as nuclei around which phenomena of living matter have been clustered. One is a structural or mechanistic idea, the orientation of molecules in the surface or gel region. The other is the analogy between the laws which regulate gases and solutions and the laws that may be applied to colloids when swelling pressure, surface region, and colloid potential are substituted for ordinary pres-

[40] Alexander, J., and B. Bridges, "Colloid Chemistry," Chemical Catalog Co., New York City, Vol. **II**, p. 17, 1928; Ostwald, Wm., *Z. Ver. deut. Ing.*, **73**, 3 (1929).

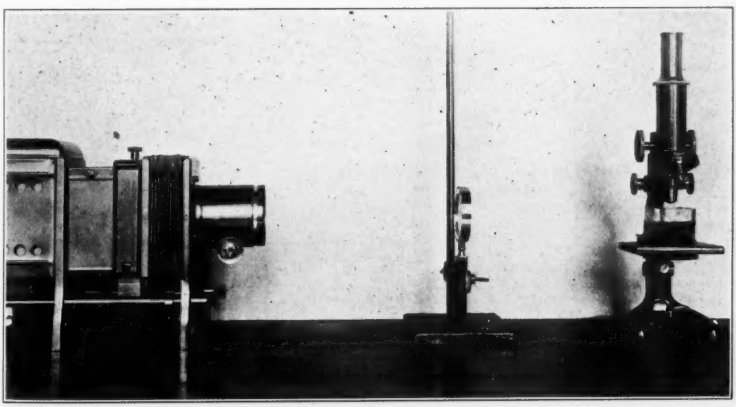
sure, volume, and temperature. Adsorption, electrical and chemical responses to mechanical stimuli, nerve and muscle action, extensibility, periodicity, and catalysis have been considered in the light of molecular orientation and colloid dynamics. It may even be possible to extend existing physical concepts so that the mysterious vital energy will become a measurable quantity and thus lose much of its mystery.

A BROWNIAN MOVEMENT APPARATUS

HARRY CLIFFORD DOANE AND WILLIAM A. DOW, GRAND RAPIDS JUNIOR COLLEGE, GRAND RAPIDS, MICHIGAN

The front lens of the projection lantern is covered with a piece of opaque cardboard having an opening $^1/_8$ inch in diameter near the center.

A pencil of light from the lantern is focused, by means of a double-convex lens (reading glass), just below the surface of a colloidal solution of arsenious sulfide contained in a rectangular glass dish. This colloidal solution is prepared by adding a saturated solution of hydrogen sulfide,



drop by drop, to a dilute solution of arsenious acid until upon shaking a slight yellow coloration is produced. The latter solution is prepared by refluxing 2 g. of As_2O_3 with 100 cc. of distilled water until dissolved. A portion of this solution is then diluted with nine volumes of distilled water. The Brownian movement is observed against a dark background by focusing a low powered (100 diameters) microscope in the beam of light passing through the solution. Dust and arsenious sulfide particles appear as points of light moving in zig-zag paths. Since the smaller particles are of colloidal size, or at least approach it, this apparatus has proved useful in explaining the principle of the ultramicroscope.

INSECTS AND CHEMISTRY[1,2]

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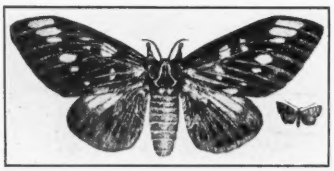
A large field for endeavor, hardly touched, is still open for chemists. This field concerns itself with the greatest and most diversified group of animals in existence. The number of insect species already known and described is about 400,000, but Dr. L. O. Howard, Chief of the Bureau of Entomology, U. S. Department of Agriculture, states that it is safe to estimate the total number of existing species as at least one million. Although the size of the insects is small, they make up for this in numbers. Shelford, Weiss, and others interested in the ecology of insects have estimated that from 200 to 5000 insects may make one square yard of a vacant city lot their happy hunting grounds.

In geological times (*Carboniferous*), when everything was done on a grand scale, there were insects about one-fourth of a meter long. It should be remembered that the large tropical so-called "thousand-feet" which are occasionally exhibited, are not insects. Like the spiders they belong in another class. The largest insect known at present is a Brazilian nocturnal insect 280 mm. long. At the other extreme are some small beetles which are only 0.25 mm. in length. Thus, the insects occupy, as regards size, an intermediate place among animals, though some insects are smaller than the largest protozoans and others are longer than the smallest vertebrates.



INSECTS OF DIFFERENT SIZES BELONGING TO THE SAME FAMILY

The large one, *Citheronia regalis*, is greatly reduced and the small one, *pyralis costalis*, slightly enlarged.

Insects in Relation to Plants

Some of these insects are distinctly beneficial to man; a large group is apparently of "no earthly use," and still another group is injurious. In common with other animals insects depend for food primarily upon the plant world. No other animals, however, sustain such intimate and complex relations to plants as insects do. The more luxuriant and varied the flora, the more abundant and diversified is its accompanying insect fauna. Insects have become profoundly modified in their use of all kinds and all parts of plants for food and shelter. Plants themselves have

[1] Journal series paper of the N. J. Agri. Expt. Sta., Dept. of Sewage Disposal.

[2] The illustrations accompanying this article have been taken from a number of publications, notably from *Felt, N. Y. Museum, N. J. Agr. Exp. Sta. Reports, U. S. Dept. of Agr. Bulletins, Fernald, Applied Entom.*

been modified, as shown in their protective devices against unwelcome insects, in the curious formation known as "galls," the various plants which

INSECT GALLS (1, 2, 3) AND TREE HOPPER EGGS (4), BY WHICH PLANTS PROTECT THEMSELVES AGAINST INSECTS

subsist on insects and especially the floral adaptations for cross-pollination through the agency of insect visitors. Although insects have laid

plants under contribution, the latter have not only vigorously sustained the attack but have even pressed the enemy into their own service.

Insects in Relation to Other Animals

Insects may derive their food from other animals (parasites like lice, fleas, ticks) or may themselves be food for other animals, especially fishes and birds. They try to protect themselves more or less effectively by various means, like hairs, stings, odors, flavors, and irritants.

Insects in Relation to Man

A great many insects eminently successful from their own standpoint interfere seriously with the interests of man. On the other hand, many insects are directly or indirectly very useful to man and their services are important. Insects destroy cultivated plants, infest domestic animals, injure food, manufactured articles, etc., and molest or harm man himself. The cultivation of a plant in great quantities offers an unusual opportunity for the increase of its insect inhabitants. The number of species affecting one kind of plant—to say nothing of the number of individuals—is often great. Corn, for instance, is attacked by about 200 species, apple by 400, and oak probably by 1000 species.

INSECTS PROTECT THEMSELVES BY IMITATING OTHERS

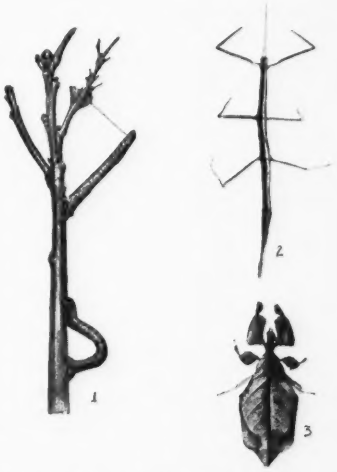
One of the butterflies has a disagreeable odor and taste, so that birds will not eat them; the other has not. One of the bees has a stinging apparatus; the other has not. 1, *Anosia plexippus*, the "model;" 2, *Basilarchia archippas*, the "mimic;" 3, drone bee; 4, drone fly.

The benefits derived from insects should be compared with the injuries. Insects are useful as checks upon noxious insects and plants (weeds), as pollenizers of flowers, as scavengers, as sources for clothing (particularly silk), and as food for birds and fish. As scavengers they are of great benefit, consuming incalculable quantities of all kinds of dead and decaying animal and vegetable matter. If it were not for these insects, tons of decomposing materials neglected by man would be left exposed as an eyesore to the community and a menace to public health.

Losses Caused by Insects

To ascertain how much man loses by the attacks of injurious insects is a difficult task. The destruction of crops, both growing and in storage, of household goods, food, forests and wood cut therefrom, injuries to domestic animals and their products, can be more or less accurately estimated. But when we consider attacks upon man by disease-carrying insects, resulting in loss of time from productive labor or even by death and the actual cost connected with illness, the problem becomes extremely complicated. About two years ago I heard a well-known business man telling an audience that his father, a prominent banker in the prime of life, was bitten by malaria mosquitoes while in the South on business He died on his way home and the economic loss was conservatively estimated to be $72,000.

A number of serious diseases of man are due to insects which serve as carriers of disease-producing organisms. Among these are malaria, the typhoid, typhus, and yellow fevers and the bubonic plague, besides others of less importance. With hundreds of thousands of illnesses from these diseases each year, the loss of time from productive labor is very large. It has been estimated that the loss of labor by sickness and death caused by malaria alone is at least $100,000,000 and by all insect-borne diseases is over $350,000,000 each year in the United States. In addition, there are many places in this country where the soil is rich and would pay well if cultivated but where man cannot live under the existing conditions because of the presence of insects and the diseases they carry.



INSECTS MAKE THEMSELVES RESEMBLE BRANCHES AND LEAVES TO AVOID ATTRACTING

Note the caterpillar suspended by a silk thread resembling a small twig. 1, Inch worm; 2, Common Walking-stick; 3, Tropical "Leaf-insect" (*Pulchriplyllium scythe*) about one-third of its natural size.

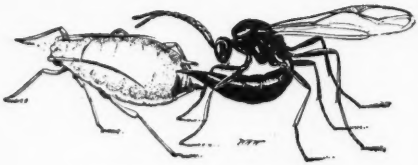
Food consumption by insects results in a direct reduction of the wealth of the country as a whole. To put a value on the destruction of crops a number of factors must be taken into consideration and only estimates can be made since we have never had a year without insects and have no definite criterion by which to judge. However, in order to get a slight idea of the amount of destruction ordinarily caused by insects, the following statement on the average value of the crops for the five years, 1913–1917, as

given in the reports of the U. S. Department of Agriculture and other sources, might serve as an index.

Field crops[1]	$833,660,000
Animals and their products	$431,450,000
Forests, forest products, etc.	$300,000,000
Loss by human diseases and death	$350,000,000
Farms, wood lots	$100,000,000

[1] Taken from Fernald, "Applied Entomology," McGraw Hill, New York, 1926.

Losses due to injury of shade trees, shrubs, plants, household goods, foods, fruit, and truck crops cannot be closely figured, but it is safe to place the loss to the United States due to injurious insects as being not far from $2,000,000,000 each year.



BENEFICIAL WORK OF INSECTS

Upper: eggs of a parasite bursting through skin of caterpiller.

Lower (greatly enlarged): Fly laying egg in body of plant-louse. When the egg hatches, the larva eats the inside of the louse.

Prevention of Losses

What is being done to prevent these losses in wealth and comfort? Entomologists have for years described and cataloged the great variety of insects; their work is not yet half done. Economic entomologists are busy with control measures, trying numerous insecticides, fumigants, baits, and traps. Mosquito workers are engaged in draining land, oiling stagnant water and recently certain poisons have been used to combat mosquitoes detrimental to health and comfort. All this work produces results, but far more could be done and greater efficiency reached if more were known about the basic principles underlying control measures.

Opportunities for Young Chemists

The whole question of insect control, which is prevention of economic losses in its broadest aspects, including health and comfort to man and beast, can be divided into two main subjects: (1) the physiology and chemistry of insects and (2) production of cheap and efficient insecticides.

What do we know about these two broad subjects? Let us take two

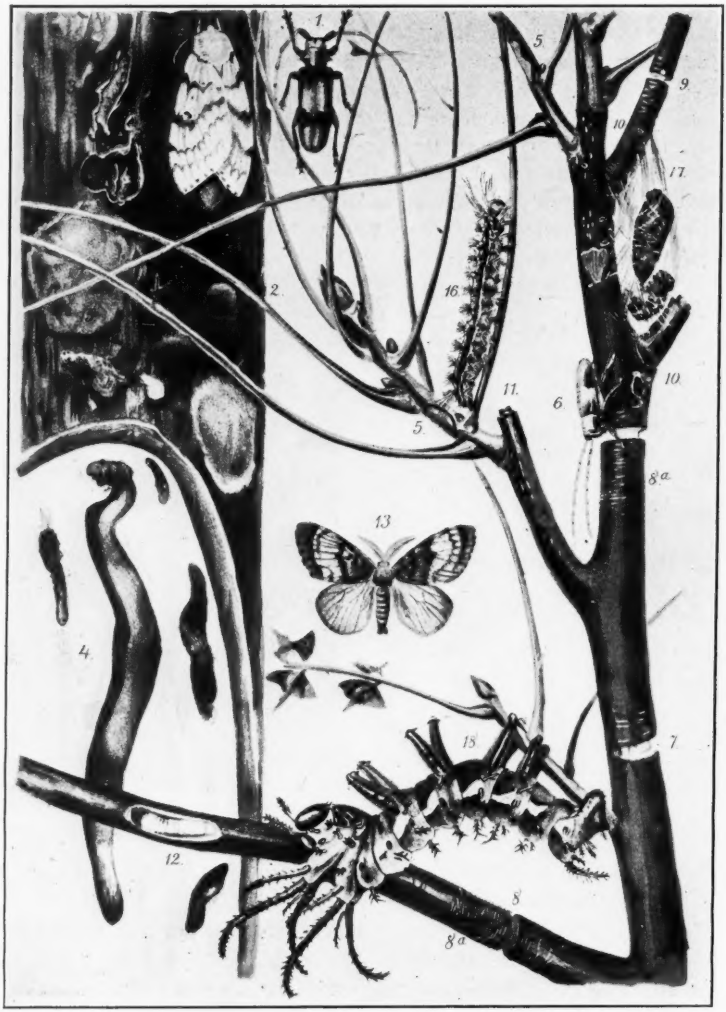
or three examples. Mosquitoes breed in water. Why? Because during the first stages of their development they find conditions suitable for existence. Some species of mosquitoes breed in certain types of water while others do not. There seems to be preference. Why, we do not know. Mosquito breeding in a certain pool is prolific, while in a pool across the road and apparently much the same no breeding occurs for years. Why? If we knew, perhaps a better and more economical way of control would be found. What is the specific substance or substances that attract mosquitoes to man and animals? We know that certain substances and factors incite mosquitoes to bite, but we do not know what attracts them. Why are certain men more prone to attack than others?

PARTIAL AND TOTAL DEFOLIATION OF TREES BY INSECTS

What substances will repel mosquitoes permanently? All are chemical problems waiting to be solved.

Certain insects attack corn or cotton or tobacco and no other crops. Why? These crops are subject to greater attack during certain stages of growth. Why? It is because the chemical composition of the plants attracts only certain insects and generally during the time that the chemical processes in the plant are most active. What is the relation of the chemical composition of the insect to the chemical changes taking place in plants? If we could solve a few of these problems we would be on the road to real understanding and efficient control.

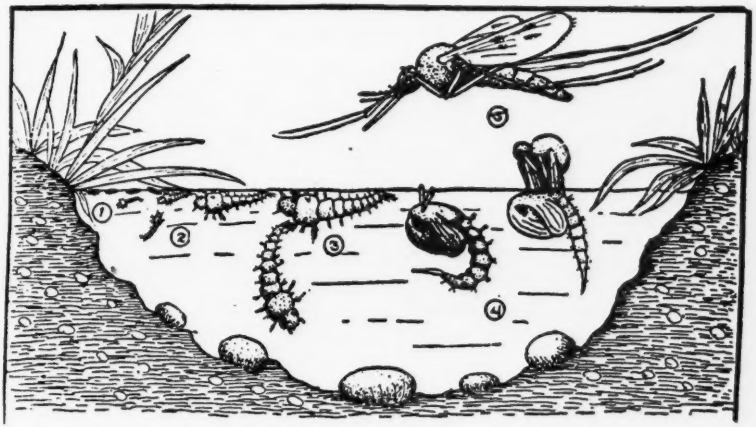
What about the second subject, production of cheap and efficient in-



DESTRUCTION OF TREES BY INSECTS

1–5, Hickory borer; 6–12, Twig girdler; 13–17, Gipsy moth; 18, Hickory horned devil (partly grown larva)

secticides? Most of the insecticides in use have been found more or less accidentally. Daily, large numbers of men are trying out in a somewhat haphazard way chemicals which might possibly be of use in insect control. In a very few instances a more systematic way is followed. Certain organic compounds and their derivatives are tested, but real investigations are hampered by the fact that we know next to nothing about the chemical reactions taking place inside the animal we are trying to control. As soon as there is promise of a new insecticide, manufacturers are only too glad to make it. We know that the presence of alkaloids, essential oils, acids, or gummy substances in plants are often of the greatest importance in making the plants immune to insect attack. We know also that certain of these alkaloids, oils, and acids kill when the insects come into contact



LIFE CYCLE OF MALARIA MOSQUITO

1, Eggs floating on surface of water; 2, young larvae; 3, full-grown larvae; 4, pupa; 5, adult emerging from pupa and adult just emerged.

with them, either by touching, eating, or breathing, but why they kill or do not kill under certain conditions is mostly a matter of speculation.

Physiology of Insects

The bony structure of insects is on the outside of their bodies instead of on the interior as in vertebrates. It is obvious that from an engineering point of view, states Dr. L. O. Howard, an insect limb with its skeleton outside, other things being equal, is three times stronger than a limb of a man. The horn-like covering substance is an albuminoid and neither attacked by dilute alkaline substance nor by acid. This substance covers and protects the insect's entire body. The muscles exposed in human

beings to the slightest injury, and attached as they are to the inner bones, are in insects covered and protected by the skeleton. They function better from the numerous attachments to ridges along the inner side of the covering. Moreover, the insect's skeleton is composed of waste material, while the bony skeleton of man is composed largely of organic intercellular substances and inorganic materials, chiefly calcium and magnesium phosphates and calcium carbonate. Man's diet must therefore be much more carefully selected than that of insects. Fortunately for man, insects are capable of breathing through small openings in their body so that in control measures, substances which will penetrate into these breathing pores can be employed. However, these breathing pores are extremely small and only substances with a surface tension lower than water will enter. This is one of the reasons why poisons used for spraying (contact insecticides) are often mixed with soapy water. At the same time such mixtures will spread better over the insect and adhere better to its body, but plants or foliage on which the insects are feeding are as a rule far more sensitive to poisons than the insects.

COMPARISON OF SKELETONS OF DOG AND INSECT

Stomach Insecticides

When insecticides are sprayed on fruit and foliage (arsenicals, for instance) they are placed there for the purpose of being eaten by the insects (stomach insecticides). The first problem arises then to make an insecticide which will adhere to the fruit in sufficient concentration to kill the insect, but will not injure the fruit or trees. It might be done by making the chemical more or less insoluble or giving it a coating of protective colloids; (2) by making a poison which is not affected by atmospheric conditions (rain, light, etc.), or by the gases in the atmosphere and those produced by living plants (CO_2 mainly) but which, when eaten, becomes at once soluble so that the poison can be carried through the body of the insect and kill it; (3) by preparing chemicals which are poisonous to insects but not to plants. Attempts have been made to produce a so-called protective coating around the particles of insecticides, but this is only a beginning, and there is considerable room for improvement. Making the chemical more or less insoluble, so that foliage will not "burn," results as a rule in less effective poisons. The second method of attack would necessitate the use of a fairly stable substance that would dissolve when coming in contact with the digestive juices of the insect. We know very little about the

physiological process which takes place in an insect. We do know for a few isolated cases that a part of the digestive tract is acid and another part alkaline. The reaction of the juices seems to vary. It is clear, therefore, that we must know more about these gastric juices, the enzymes involved and the general question of nutrition before a good attempt can be made to produce poisons which will be dissolved in the insect and will be most fatal. The third method of attack is possibly the most promising, but before a real attempt can be made we need a large amount of study and research along biochemical lines. Economic entomologists realize more and more that skilled chemists are needed to work with them in order to solve a number of problems. The writer has been employed for several years as biochemist in entomology at the New Jersey Agricultural Experiment Station and can safely say that biochemistry of insects will become of necessity a branch of chemical science far more important than we now can imagine.

POWER SPRAYING WITH ARSENIC
Insert shows arsenic on leaves taken from top of tree.

Insects Attack Almost Everything

Aside from the insects which attack living plants we have to deal with others. In fact insects feed upon almost everything. The carnivorous species feed fortunately mostly on other insects or on dead animals, although, as I have said, a number of them subsist on living vertebrates, like lice, fleas, ticks, etc. Still others, feeding on live and dead woods, garments, rugs, carpets, practically all stored food of any kind found in homes and warehouses, must be attacked in an entirely different way. The practice is to fumigate the food, wood, trees, etc., and particular care must be taken not to kill the trees or poison the foods. During the last ten years some work has been done to find chemicals which are sufficiently volatile and poisonous to kill the insects without injuring the host. However, this work is also

only at its beginning, because there are large numbers of organic chemicals, their derivatives and combinations which have never been tried.

OILING OF SHALLOW POOLS ALONG ROADSIDES

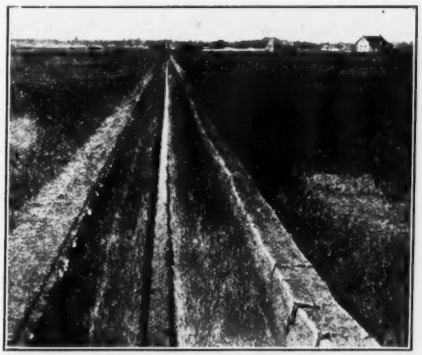
OILING OF CATCHBASINS AGAINST MOSQUITOES

Here again a systematic search must be made by competent chemists working in conjunction with entomologists to find substances which can be made cheaply, are practical in application, and relatively non-poisonous to the user.

Problems Not Simple

The reader should not think that the problems are simple. The great adaptability of the insects makes the problems involved and difficult to solve. Take for instance the case cited by Dr. Howard of the drugstore beetle. This beetle accommodates itself to the conditions existing in the apothecary shops and eats everything from face powders to Spanish flies. Cayenne pepper, mustard plasters, and even weak insect powders seem to be palatable to it. Insects live in strong alkaline water of the Great Salt Lake, others in salt mines, and one species lives in petroleum in California; verily their adaptability is extraordinary.

The line of attack against economic insects which spend a part of their lives in water like mosquitoes and the sewage fly must again be entirely different. Killing these insects while they are on the wing is placing the cart before the horse. The control of mosquito breeding has been thus far mainly an engineering problem. Chemical studies made during the last few years on the reasons why mosquitoes breed in certain places emphasize only the abundance of interesting and important problems. Small gray flies inhabiting in their larval stage certain parts of sewage purification works breed by the billions and create considerable nuisance aside from the fact that they may carry diseases. The fly is so small that it finds its way easily through screens and cracks in the houses. If a wind-borne cloud strikes a house, flies will be found in the noses, ears, and mouths of the occupants as well as in the butter in the ice box. There are numerous other examples of insect pests which could be cited, as well as the need for chemical investigations connected with them, but to recount them would only multiply repetitions.



DRAINAGE OF MEADOWS BY DITCHING AGAINST MOSQUITOES

Lest the reader may think that the so-called "balance of nature" will take care of all things, I will cite a few sentences of the eminent and foresighted entomologist, Dr. L. O. Howard. He states that:

> The human species has been creating a tremendous disturbance in the world of nature. In regions where things had pretty well settled down and where the interplay of natural facts had approximately adjusted itself, as in, say, America before Columbus, man, rapidly increasing in number, has altered conditions in the most extraordinary way.

Nature tries to adjust herself to the new conditions created by man, but nature has a hard job, although she is powerful and resourceful. Man in growing food for himself creates more and more conditions peculiarly favorable for certain kinds of insects, and they are multiplying in a way that would never have happened, if man was not providing and placing food for the insects in the most inviting way, fairly begging them to do their worst and to test to the utmost their extraordinary powers of multiplication. For instance the corn borer would not today be the menace to our greatest agricultural crop if we did not grow the crop just as we do, in enormous fields, leaving the stalks stand through the winter. The cotton boll weevil would not have spread over the whole cotton belt and caused many hundreds of millions of dollars' worth of damage had it not found, on crossing the Rio Grande, that cotton was cultivated and harvested in just the way to encourage its multiplication and spread to the extreme.

The United States is spending some ten million dollars to check the corn borer. To give an idea of the possibilities of certain insects in the way of rapid increase, the recent estimate of Prof. Herrick of Cornell, based upon careful weighings and calculations, shows that a cabbage louse might have in less than a year, in Central New York, where there is food enough, so many descendants that although each one weighs little more than one milligram, the mass of the whole would weigh more than 822,000,000 tons. If the human population of the earth is estimated to be two billion and the average weight 150 pounds there is a human weight of about 150,000,000 tons or in other words the descendants of one plant louse in one season would weigh more than five times as much as all the people of the world.

Field for Young Chemists

It is evident from the enumeration of a few of the problems that this particular field for chemists is by no means overcrowded. It will be evident also that poorly trained and disinterested young men will have to continue their struggle in routine and consequently poorly paid work. These problems call for well-trained men who have initiative and imagination, who have the curiosity to inquire and who are capable and willing to leave the beaten track and devote themselves to these promising but difficult lines of work. Let me close with a few sentences of that scientist, Dr. Howard, quoted several times before.

For years man has been called upon to meet the individual emergencies in the way of insect control. He has attacked these emergencies with the weapons most immediately at hand and has been more or less successful. But he has not seen the problem as a whole. He has not seen the combined intellectual possibilities of his own species. He does not understand insects. He is ignorant of many of the basic problems bound up with their lives. Until he knows everything about them, he cannot conduct an intelligent fight.

A part of the "combined intellectual possibilities" must be furnished by chemists so that the chemical "basic problems" may be understood and knowledge made available for "an intelligent fight" against the insect plague in the future.

RHEOLOGY. I. THE NATURE OF FLUID FLOW

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The science of the flow of matter very early got off to a brave start, when the Greek philosopher Heraclitus announced that "everything flows." The flow of water in pipes, the plasticity of clay and bronze, even the flow of the sand in the "hour glass" offered a challenge to investigators, but progress has not kept pace with the demands of science and industry. Surely no one would think of consulting a work on hydraulics in designing a new alloy, artificial textile or lacquer. What has been the matter? Certainly cats' backs and thunderstorms could hardly have presented so promising a subject for the investigator at the beginning, for electricity is invisible; yet the science of the flow of electricity has never faltered and a host of volumes are required for its exposition, while the science of the flow of matter has lagged at the starting post. In fact, were one to speak of the *science of matter* as we speak of the science of electricity, no one would know what was being referred to. So an entirely new term for the science of flow was suggested at the Third Plasticity Symposium, the name *rheology*, which I am adopting here.

It needs to be pointed out at once that ordinary flow in streams and pipes is indeed hydraulic and it is this type of flow which engaged much of the attention of the early investigators, including many of the most celebrated, such as Galileo, Newton, Napier, and Bernouilli. They observed that hydraulic flow is turbulent flow and quite complex in character but it was only in 1846 that the simpler linear fluid flow was demonstrated by the Frenchman, Poiseuille. He was a physiologist interested in the flow of blood in the capillaries of the body but most of his experiments were made with water in glass capillaries and he thus discovered by accident that flow in very narrow channels or at low velocities is *linear* in character, giving a simple type of flow. This type of flow had been suggested by Newton but not demonstrated. The difference between hydraulic flow and fluid flow may be stated very simply, for the resistance to hydraulic flow increases nearly as the square of the velocity but the resistance to linear fluid flow increases merely as the first power of the velocity. This law is to the flow of matter what Ohm's Law is to the flow of electricity, *i. e.*, it is simple and exact and upon it rests the development of the science of fluid flow. It may be stated in the "elegant language of mathematics" as:

$$v = \frac{Fr}{\eta} \qquad (1)^1$$

$$= \varphi Fr \qquad (2)$$

[1] In the above formula v is the velocity imparted to one layer in reference to another at a distance r, by the shearing stress F.

where η is defined as the viscosity and φ as the fluidity. If we consider a sea of fluid of indefinite area but of unit depth subjected to a unit shearing stress, the velocity imparted to the surface is a measure of the fluidity. This is the formal definition of the unit of fluidity, for which the name *rhe* has been suggested. The *poise* is the name of the reciprocal unit of viscosity, but the *centipoise* is more familiar. This is preferred because the viscosity of water at 20°C. is almost exactly one centipoise and therefore all absolute viscosities expressed in centipoises are really *specific* at the same time.

In order to make the argument clearer, I will here present some simple demonstrations. A tubulated bell-jar was supported in an inverted position at a little distance above the table (Figure 1). By experiment it was found that 50 cm.^{3} of water ran out of the tubulure in a single second, but it may be surprising to learn that on substituting linseed oil, which is comparatively viscid, the time of efflux of 50 cm.^{3} still turned out to be one second; but this is in accordance with the principle of hydraulic flow that the rate of flow is nearly independent of the viscosity of the liquid. However on placing in the tubulure of the container a rubber stopper carrying a narrow capillary 18 cm. long and repeating the experiment, very different results were obtained. The time of efflux for 10 cm.^{3} of water at 26°C. was 3.7 minutes while that of linseed oil at the same temperature was 140 minutes. Since the fluidity of water at 26°C. is 114 and of linseed oil 2.6, these rough measurements demonstrate that in this second type of flow, the rate of efflux is directly proportional to the fluidity, the flow of the water being about forty times as fast as the linseed oil. By using an efflux tube 4.4 mm. in diameter and 4.5 cm. long an intermediate result was obtained, the water flowing only 5 times as fast as the linseed oil. Sir Osborne Reynolds and others have studied carefully the transition from linear to turbulent flow and using an instrument like that shown in Figure 2 one can make quite precise measurements.

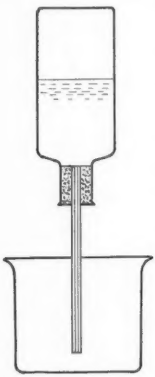

FIGURE 1

Reference has been made to the resemblance of the law of Newton-Poiseuille to Ohm's law. A few experiments will help to bring out this similarity. In electricity we learn that when conductors are in series, their resistances are additive but when the conductors are in parallel their conductances are additive. Similarly, in fluid flow when fluids flow side by side as in true solution the fluidities are additive, but when the fluids flow in series, as in certain emulsions or poorly mixed liquids, the viscosities are additive.

We will consider first the simple case of linseed oil and water which are

immiscible. Adding 5 cm.^{3} of oil and an equal volume of water to the simple viscometer used above, we find the time for the two liquids to flow out the one after the other to be 80 minutes. From the earlier measurements, we calculate the value to be $\frac{3.7 + 140}{2}$ or a little over 70 minutes. Since the times of efflux have been shown to be proportional to the viscosity in these experiments, we conclude that the viscosities are additive[2] or

$$\eta = \eta_A + \eta_B$$

If the linseed oil and water had gone into solution the time of efflux would have been quite different and we can calculate what it should have been although we cannot verify the value by measurement with this particular pair of liquids. Since the fluidity is inversely proportional to the time of efflux and

$$\varphi = \varphi_A + \varphi_B$$

the calculated time of flow is 7 minutes. As a matter of fact a fine emulsion in which the drops did not completely close the capillary flowed through the capillary in 20 minutes.

The flow of solids gives a third type of flow, known as plastic flow. It is characteristic of solids that they are able to maintain their shape indefinitely under small shearing stresses but that they can be deformed more or less readily by stresses which exceed a certain critical value, known as the yield value. Since fluids all yield to any stress, no matter how small, this distinction between solids and fluids is fundamental. It is on the basis of this distinction that one is able to say that pitch and glass are really very viscous liquids and that paint and butter are soft solids. The discussion of this type of flow will be postponed.

The question proposed at the beginning of this article as to why the study of the flow of matter has lagged, we are now prepared to answer.

1. The hydraulicians were not aware that there is more than the one type of flow, and the type with which they were occupied did not help much in solving problems concerning the constitution of matter.

2. The analogy of Poiseuille's law to Ohm's law pointed out above has been overlooked, with the result that it has been incorrectly assumed that the viscosities of true solutions should be additive. This error would have been quickly corrected by a study of experimental results, but unfortunately on mixing many pairs of liquids there results some sort of chemical combination or dissociation with a concomitant change in the fluidity. But this seeming evil will in time prove to be a blessing, since the fluidity method is ideally suited to follow these chemical changes.

[2] The discrepancy here may be reduced by a more carefully designed apparatus. For example, the observed time in this experiment is a little low because the film of water facilitates, *i. e.*, "lubricates," the flow of the oil.

3. Perhaps it is only to be expected that so long as there was uncertainty concerning the fundamental theory, there would be little incentive to exact measurement. It is a misfortune that much of the data in the literature is of such a low order of accuracy, due to omission of corrections necessary in precise measurements. As an indication of the lack of importance still attached to this property, a recent examination of some thirty texts on physics and physical chemistry failed to disclose one which described a method for the exact determination of the property. Very unfortunately the texts either do not mention the corrections referred to above or else they make the misleading statement that they are negligible, when as a matter of fact it has been shown that they may amount to over ten per cent. It is so very simple to test one's results by the use of several shearing stresses that there will doubtless be a rapid improvement in our data in the next few years.

The greatest difficulty in the exact measurement of fluidity is in the precise measurement of the average diameter of a capillary tube (Figure 2). As the easiest way to solve the Alexandrian knot was to cut it, so the simplest way is to adopt as *standard* the average value for water at, let us

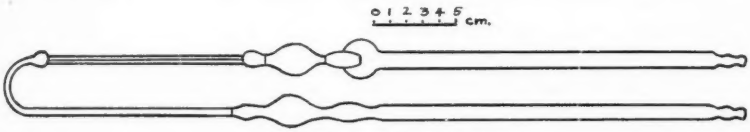

FIGURE 2.—VISCOMETER

say, 20°C., which would be nearly 100 rhes. Even now workers assume some substance as standard for the purposes of calibration but the trouble is that they do not agree as to the value for the standard, which is an entirely unnecessary cause of inaccuracy. The value could be arrived at by a commission and adopted for all time as in the derivation of the weight of the kilogram from the cubic decimeter of water, or the value could be changed from time to time as are the atomic weights.

We may now briefly consider how fluidity data may further our knowledge, and point out at once that in the hands of Maxwell the viscosity of gases very early served as a principal buttress to the kinetic theory of gases. On the basis of the theory, Maxwell predicted that the viscosity of a gas would prove to be nearly independent of the pressure and when this proved to be the case, it was regarded as a strong proof because the result was so unexpected. The viscosity of air was used by J. J. Thomson and Millikan in the determination of the charge on the electron.

An understanding of fluidity is necessary in the consideration of conductivity of solutions, cataphoresis, diffusion, rate of reaction, rate of crystallization, etc., but all of these important subjects will be left out of

consideration here in order to focus our attention upon what seems to be the most fundamental fluidity relationship.

For many years evidence was accumulating to prove that in liquids, in contrast with gases, the fluidity is closely related to the volume. Thus in warming a liquid its fluidity increases, on putting it under pressure its fluidity decreases, and on mixing with another liquid if the volume decreases, the fluidity also in general decreases. The Russian chemist Batschinski first showed that in unassociated liquids there is a linear relationship between the two properties. As the volume is reduced, either by temperature or other means, if we name the particular molar volume V at which the fluidity would become zero the *limiting volume*, designated with the symbol W, then we may state the law that the fluidity of a liquid is directly proportional to its *free volume*, or

$$\varphi = K\,(V - W)$$

where the free volume $(V-W)$ is the difference between the molar volume at any given condition and the limiting volume and K is a constant for each liquid. Leaving the constant out of consideration, this law signifies that the fluidity is not dependent upon the temperature or the pressure but solely upon the volume not occupied by the molecules themselves. Since the molar volume and the fluidity are easily measured, there is placed at our disposal a means for calculating the volumes of the molecules, provided the constant K can be evaluated, which Batschinski has indicated may be possible.

It strikes one as curious that simply observing the rate of flow through a capillary tube can give one valuable information in regard to the size of the molecules that make up the liquid, but the operations used in getting the vapor density are of the same order of complexity. As a matter of fact our whole body of knowledge about matter, both chemical and physical, is derived from the measurement of what may be called simple physical properties.

However this may be, there is an obvious need for a convenient and reliable method for obtaining the molecular weights of pure liquids and of the compounds which they form with substances dissolved in them, for our laws of osmotic pressure, freezing point, conductivity, etc., all seem to break down and the modern physical chemist seems to be helpless before those *bêtes noires* of association and hydration.

No one has yet made direct use of the Batschinski relation in obtaining the molecular weight. The author has shown that liquids are most comparable at temperatures where the fluidities are identical; *e. g.*, 200 or 300 rhes. The temperatures are additive; and the following atomic constants have been obtained:

Atom or grouping	$\varphi = 200$	$\varphi = 300$
Carbon	−95.7	−110.2
Hydrogen	59.2	67.8
Oxygen	24.2	27.1
Chlorine	113.9	131.7
Iso	−7.6	−8.2
Double bond	114.4	131.3

As illustrations, the absolute temperature required to give heptane (C_7H_{16}) a fluidity of 200 rhes is 276.1° and the calculated value is $(16 \times 59.2) - (7 \times 95.7) = 277.3°$; or methylpropylether requires an absolute temperature of 265.5° to give it a fluidity of 300 rhes and the calculated value is $(10 \times 67.8) + 27.1 - (4 \times 110.2) = 264.3°$. It perhaps goes without saying that the negative value of carbon applies only to compounds of carbon containing other elements with positive values. If for any reason the carbon atoms lack their full complement of satellite atoms, their absence must be compensated for and it is not without interest to note that the value of the "double bond" is only four degrees less than for two hydrogen atoms. The more symmetrical *iso* compound seems to require a slightly lower temperature to produce a given fluidity, but the effect is small. Whether the effect is real or not will be determined as soon as sufficient data is accumulated. Here again that *bête noire* of association rises before us, for there is a great class of substances which we have come to regard as associated which do not give close agreement between the observed and calculated temperatures.

Taking as an extreme example the case of water, the observed temperature required to give a fluidity of 200 is 328.9° K whereas the calculated is only $(2 \times 59.2) + 24.2 = 142.6°$, but since the temperatures are additive

$$142.6x = 328.9,$$

so that the association factor $x = 2.31$, at 56°C. It is 2.20 at 85°C. This is but a single example of which many might be given. The important thing is to apply tests to the values obtained in order to prove whether they are correct or not. There are now several ways which have been proposed for calculating the molecular weight of associated liquids. It can be said of the fluidity method that it agrees with the others as well as they agree with each other. This is valuable as confirmatory evidence but the method must find its merit in its directness and simplicity. The very important conclusion here is that water is not made up exclusively of simple molecules of H_2O called hydrol or even of trihydrol $(H_2O)_3$. It is more likely a mixture of the two in equilibrium, but we see that a change of thirty degrees only changes the association of water by five per cent. We can therefore consider liquid water as a substance with a molecular weight of roughly 41 instead of 18. This change in our conceptions will be highly advantageous.

Since an unfamiliar subject strikes the reader with strangeness if not indeed dismay, it may be well before closing this part to present a photograph of a model of the fluidity pressure isothermals of carbon dioxide prepared by Mr. Baxter Lowe (Figure 3). The coördinates of pressures, fluidities, and temperatures are measured off on the boards painted black. The model was made from plaster of Paris as accurately as the available data would permit. The curve *ABCD* presents a close analogy to the well-known pressure-volume isothermal of carbon dioxide except that in the gaseous state *CD* there is a marked difference due to a new cause of viscous resistance (diffusional viscosity). In the liquid state the effect of pressure on the fluidity *AB* is seen to be very small. Above the critical temperature *EG* the effect of pressure on the fluidity is quite different, becoming less and less as the temperature is raised. One is even faced by the paradox of a gas at a very high temperature having a lower fluidity, *i. e.*, higher viscosity than it would have at high pressure in the liquid state. The effect of temperature on the fluidity of liquids is to *increase* it in a nearly linear manner *AE* but the effect of temperature on gases is to decrease it *DG*. Since this model represents the fluidity model of any substance near its critical temperature *F*, much may be learned by a careful study of it.

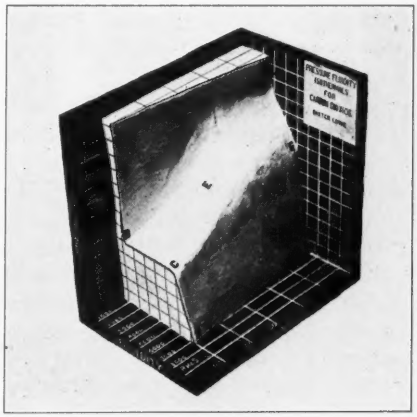

FIGURE 3

Native Insect Enemies Catching Up with Weevil. The native insect enemies of the cotton boll weevil, long considered negligible factors in the warfare against the invader, are at last beginning to make themselves felt, in the opinion of Edgar F. Grossman of the Florida Agricultural Experiment Station. Mr. Grossman's studies are briefly reviewed in a recent issue of *Science*.

There are some 55 species of insects that attack the boll weevil, either as parasites or predators. They are all native American species, whereas the weevil is a foreigner, coming originally from Mexico. In its first rush of invasion it got far ahead of the capacity of its enemies to check it, but within the past 15 years, Mr. Grossman says, evidence has been coming in, tending to show that the native insect forces are coming into action as really effective auxiliaries of the standard poison and culture methods of keeping the weevil down.—*Science Service*

EDUCATIONAL AIMS IN TEACHING ELEMENTARY CHEMISTRY

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For the past few years the need of reorganizing science courses in secondary schools has been widely recognized. Such a need has been due to lack of uniformity in science subjects because of the variation of purposes, the increasing number of sciences offered, the development of intensive specialization within the various sciences, the lack of sequence in which they are frequently given and the wide variation in methods and contents. Chemistry, an experimental science, was originally admitted to a place in high-school programs on the assumption that its aim would be to contribute something to the pupils' mental structure in the way of discipline and knowledge. Although the manner of chemistry instruction is far from uniform today in high schools, its reorganization is being brought about chiefly in the endeavor to unify its aims.

In the earlier days chemistry was presented nearly in the form of a pure science, relieved only to the extent of descriptive matter and simple experiments which were necessary as illustrations of theories and principles under discussion. The course in laboratory instruction in all institutions seemed to have been patterned after that pursued by Liebig in Giessen. The course amounted to the preparation of a few gases after which the student was trained in qualitative and quantitative analysis. In 1846 Professor Will published an English translation of Liebig's course in qualitative analysis and its adoption served as the sole material for laboratory instruction. This form of instruction was a "cook-book" method for determining by analysis what a given substance or mixture of substances contained and tended to give the pupil a one-sided, distorted view of chemistry. He merely followed book directions and gained very little because he did not put into play his own constructiveness based on what knowledge of chemistry principles he acquired.

The first really decisive step toward fostering the importance of fuller preliminary instruction in elementary chemistry was taken by Harvard College in 1888. At that time it included chemistry for the first time among the subjects that might be offered for admission and through Professor Cooke's "Laboratory Practice," issued in the same year, defined the kind of work which it considered to be the true educational equivalent of the other and older preparatory school studies. This book, launching a new ideal in chemistry instruction was the first attempt in this country to lay out a course of laboratory work dealing adequately with the fundamental facts and laws of chemistry. The above procedure made more feasible the collaboration of laboratory and classroom work in comparison with Liebig's miscellaneous experimentation with chemical substances and cut-and-dried methods of qualitative analysis.

Prior to 1888 discussions on the best methods of teaching elementary chemistry had taken place for some years in Great Britain. A vast improvement over old methods occurred in 1889 when a committee of the British Association, appointed to consider the subject, submitted a report which included a detailed outline of the work. By discarding the analysis, it resembled the American plan but was intended for younger pupils. It made possible the change in order of sequence in the students' acts of merely following directions of another and tended to place the student more in the light of the discoverer. Cooke's plan and the English plan mentioned above contributed extensively to the rapid spread of more judicious methods of presenting science. The underlying principles of the work in chemistry in secondary schools today are the outcome of Professor Cooke's plan.

The methods of elementary chemistry instruction have changed much since the World War and very largely on account of it. The condition existing in science instruction prior to the war applying to chemistry has been ably expressed by Dewey in a lecture on "Methods in Science Teaching." In 1916 he pointed out the necessity of connecting science with daily occupations and surroundings.

> Our present methods too largely put the cart before the horse; and when we become aware of this mistake we are all too likely to cut the horse entirely loose from the cart and let him browse around at random in the pasture without going anywhere. What we need is to hitch the horse of concrete experience with daily occupations and surroundings to a cart loaded with specialized scientific knowledge. It is not the duty of high-school science to pack the cart full, that will come later. It is its part to make a good job of the hitching that every pupil who comes under its influence will always find in himself a tendency to turn his crude experiences over into a more scientific form, and to translate the bare science he reads and hears back into terms of his daily life. When we do this we shall find, I am confident, the crop of scientific specialists increase, not diminish, while we shall have a citizenship of men and women really intelligent in judging the affairs of life.

While today much of the abstruseness in elementary chemistry has been done away with, in many schools the tradition of having the pupil acquire a collection of symbols, formulas, and laws disconnectedly persists when the aim should be the showing of the application of chemistry to daily life.

The aims of instruction in elementary chemistry in this country prior to the war and very largely today perhaps would hardly harmonize with some of Dewey's characteristics found in all good educational aims. He states that:

> An educational aim must be founded upon the intrinsic activities of the given individual to be educated. . . .An aim must be capable of translation into a method of coöperating with the activities of those undergoing instruction. It must suggest the kind of environment needed to liberate and to organize their capacities.

Until the past few years elementary chemistry instruction had for its aim preparing the high-school pupil for college. The pupil acquired a working knowledge of certain laws and principles as far as chemical theory only was concerned to assist him in advanced college courses. The pupil learned that the composition of water volumetrically is one volume oxygen and two volumes hydrogen and quantitatively is one-ninth hydrogen and the remainder oxygen. He should have been concerned more with the tests for purity of water, with the removal of salts causing hardness in water, and with the treatment of contaminated water. The needs of the greater group of students, those who finish their formal schooling with the high school and who should have a general practical knowledge of chemistry as it concerns their everyday life, were not thus taken care of.

The aim of education in the modern sense is a combination of social and economic efficiency with a development in each individual of a high type of personality. Science teaching has a training function in the formation of right habits which are indirect and have general applications. The outcome of this training function is the realization of utilitarian, economic, or vocational values which assist in the contribution to the ability of the individual to support himself and family. Elementary chemistry instruction should be such that utilitarian and economic values should result.

The chief aims of elementary chemistry should be:

1. To give the pupils an idea of the importance and significance of chemistry in our national life.

Chemistry is the science which fashions from the materials found in nature other substances which are better adapted to the immediate needs of man. The layman looks upon chemistry as a magical and mysterious art and fails to appreciate the chemists' power to serve society. The student can do much to supplant this ignorance by the acquisition of a broader understanding of industrial processes. It is difficult for the average person to realize that the iron and steel used in his automobile, in construction steel, in tools, nails, etc., come from formations similar to soil. The student can better appreciate that fact when he becomes acquainted with the processes in mining the ore, in the chemistry of the blast furnace where the metallic iron is recovered from the ore, in the manufacture of the steel, etc. With his knowledge of chemistry of industrial processes the student can inform others how baking soda is made, how ordinary glass is made from sand, soda, and lime, how different grades of glass are prepared, how leather is made, how rubber is prepared, how helium is secured, how paper is made from wood pulp, how artificial perfumes and flavors are prepared, how snapshot pictures are possible, how earthenware and porcelain are made, how electroplating is carried out, where glues and gelatins come from, how inks are prepared, where lubricants come from, how matches are made, how paints and varnishes are

made, how artificial silk fibers are made, how soap is made, and give information relative to many other industrial processes.

The student should know some of the services of chemistry to agriculture to appreciate the vital importance to human welfare of the inter-relation of crops and soils. Pure food comes directly or indirectly from the soil through field crops as the transforming medium. The crops are dependent upon the available plant food in the soil and the student is the better enabled to appreciate that fact when he understands somewhat the chemical constituents of soils, the necessary elements for healthy plant growth, how acid and alkali soils are treated and how fertilizers such as nitrates, potash, ammonia, and phosphates are prepared to replace the elements plants have removed from the soil.

The student should know to a certain extent how chemistry is related to medicine which is concerned with the preservation of life. Physicians are dependent upon specific medicaments for the cure or alleviation of specific diseases. The student will better appreciate the chemists' service to medicine when he becomes acquainted with the great effort expended to improve on nature's remedies. Procaine and beta-eucaine have practically displaced nature's cocaine as a local anesthetic. Appreciation is better effected when the student learns of the use of chaulmoogric acid and its derivatives to combat leprosy, of cinchopen to relieve gout, of arsphenamine as a specific for syphilis, of luminal as a specific for epilepsy, of amyl nitrite to relieve angina pectoris, of carbon tetrachloride or thymol in conjunction with chenopodium as a cure for hookworm, of iodine for goiter, of the preparation of antitoxins, and of many other applications of chemistry to medicine.

2. *To give information of definite service to home and daily life.*

There are many applications of chemistry around the home and the things that come into the home have been connected directly or otherwise with chemistry. The student will acquire a keener insight into the conditions and demands of home life with some knowledge of chemistry. Through that science he will learn what the chief classes of foods—carbohydrates, fats, and proteins—are composed of, what makes butter rancid, what sour milk is, what baking powders contain and which one is best, of what washing and scouring powders are composed, what tarnishes silverware and how the tarnish can be removed, what vinegar is and how it can be analyzed for the acid content, what disinfectants and germicides are, what antidotes to use for poisons, what solvents to use to remove stains; such knowledge that makes the pupil feel he has actually learned chemistry that he can use.

3. *To develop specific interests, habits, and abilities which should be contributed by all sciences.*

Mather evaluates laboratory instruction from a cultural standpoint when he said:

> The patient investigation and accurate methods required to obtain desired results in the school of experimental and technical science cannot fail to impress, refine and ennoble the character of those who work in that direction.

The student through classroom and laboratory work will acquire habits, and whether they are good or otherwise will depend upon the instructor. The specific habits acquired are those that will be useful in many of the situations of everyday life and in all kinds of occupations they are of great utility. Chemistry calls for the powers of observation, discrimination, interpretation and deduction, and a high type of abstract thinking is involved. Through the study of chemistry such specific habits as, Twiss mentions, are acquired through any of the sciences, will be obtained:

1. Carefulness and skill in the manipulation of apparatus.
2. Accuracy in making measurements.
3. Careful observation of significant facts and phenomena, using hands, eyes, and ears before consulting a textbook.
4. System, order, and neatness in the arrangement of apparatus and appliances for observational and experimental work.
5. Accuracy and methodical procedure in setting down, arranging and tabulating data, and in making calculations.
6. Legible writing, clear, neat, and accurate drawing, correct spelling and punctuation, correct grammatical construction, clearness of expression in written and spoken English.
7. Good form and effective motor attitudes and expression in "making a recitation."

Chemistry does more perhaps than any other science to develop the above habits wherever laboratory facilities for instruction in that science are possible. The student has more opportunity to come in direct contact with things and secure specific habits first hand. Some one has mentioned that the caliber of the chemistry instructor is indicated by the manner of the students' "housekeeping" in the laboratory.

4. To secure an element of continuity in science by knitting together previous science work through recall and through the presentation of principles—new ones and elaboration on old ones.

In general science the pupil learned about the source and the necessity of oxygen but much more knowledge is secured when he comes directly in contact with it through the preparation of the gas from various substances and the study of its properties in the laboratory. In that beginning science the pupil also learned vicariously for the most part how water is softened. He better appreciates the service of chemistry when he can himself soften water by the proper manipulation of apparatus

and chemicals in the laboratory. Many of the principles in biology will be recalled and better understood by the use of chemical applications.

5. To help the student discover whether he has an aptitude for further work in pure or applied science and to induce such pupils to continue science studies in the university or technical school.

A number of pupils really find themselves through their study of chemistry and through their interest continue its study by specialization. Because of the interest in science furthered by elementary chemistry a few pupils are spurred on to continue their education in college while otherwise without the training formal education would cease with the high school. A course in elementary chemistry will make some students decisive in regard to their aptitudes in science.

The educational aims in teaching, beginning with chemistry should be such that they lead to (1) the appreciation of and respect for the services of chemistry to industry, (2) citizenship through rendering an appreciation of the science in advancing the welfare of society, (3) the excitement of activities relating to better ideals connected with modern home life, (4) development of specific values—interests, habits, and abilities, and (5) the pupil's discovery of his aptitudes. Chemistry teaching has been criticized because of the tendency to teach the subject merely as a pure science. The past few years have witnessed the discarding of that traditional procedure and more and more elementary chemistry is being taught from the standpoint of its fundamental relationship to society and the home.

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Insects Wiping Out Australian Cactus. Marked success in the war against the prickly-pear cactus plague of Australia is being scored by two insect genera which have been imported for the purpose. The most recent advances are reported by Prof. T. D. A. Cockerell of the University of Colorado, in a recent issue of *Science*.

One of the most successful of the insect enemies of the cactus which have been taken to the southern continent is a moth species known as *Cactoblastis cactorum*. Its caterpillars attack the prickly-pear joints avidly, and to date the moth itself has not been subject to any special damage by insect enemies of its own.

The cochineal insects, of which there are several species, have also been laying the cactus waste in parts of Australia. The use of these insects against the cactus is complicated by the fact that each species of the insect seems to have one or two favorite species of cactus on which it will feed, refusing all the rest. But much progress has been made in matching the insects with suitable cacti, with the result that considerable areas are beginning to be cleared of the pest.—*Science Service*

REFORM IN THE CHEMISTRY CURRICULUM

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The purpose of this paper is to emphasize the desirability of certain changes in the college curriculum which would make for more independent work by undergraduate students in chemistry. In order to render more than a mere lip service to a sentiment which would be acceded to in principle by nearly all teachers of chemistry, the author suggests a concrete plan for the reorganization of the chemistry curriculum so as to better secure the development of the intellectual initiative and independence of the student. Essentially, the plan consists of the insertion of *autonomous* or *tutorial* courses into the curriculum, to replace all except four fundamental present-style courses in general, analytical, organic, and physical chemistry. This paper is not at all concerned with the development of cultural or *pandemic* courses in general chemistry; the author is concerning himself only with the preparation of the student who intends to make chemistry his life-work.

There are two differences between the scientist and the *man in the street*. One difference lies in the fact that the scientist has certain tools, consisting of a method and mathematics, for delving into the secrets of nature and describing her laws. The other, and one fully as important, is contained in the fact that the successful scientist has largely overcome his intellectual inertia. Each one of us is possessed by this inertia which takes the form of a mental timidity—a fear to launch out into the dark of a new problem. If an instructor or some other guide will lead the way, we follow gladly and glibly—hence the apparent success of lecture courses in college. But our intellectual inertia remains, not one whit abated, to deter us from attacking wholeheartedly and with success the problems which we shall need to meet without guide service. The only way to overcome this inertia is to tread the paths of scientific investigation courageously alone until we gain confidence in ourselves. It should be just as much the function of the college chemistry curriculum to provide means for the student to overcome his intellectual inertia, as to provide him with the tools of the chemist.

If we consider the development of the chemistry curriculum during the past two or three decades, we find a planless expansion which has been necessitated by the growth of the field of chemistry. From a field which was adequately covered by four college courses—general, analytical, organic, and physical chemistry—the science of chemistry has expanded over hitherto undiscovered territory as well as over territory which had previously been allotted to other sciences, until now it covers such an area that no one man could hope to survey it all. The chemistry curriculum,

originally a simple instrument which satisfactorily surveyed the entire field in four years, has been endowed with a multitude of cumbersome additions in the form of specialized *courses* which make it an unwieldy thing, unable to perform the impossible function of giving the student a complete survey of the entire field, and unfit to perform the essential present-day function of preparing the student for intelligent specialization in some one branch of the science.

When one reads the pages devoted to the chemistry curriculum in almost any college catalog today, he finds, in addition to the four courses which I have suggested as fundamental, from five to twenty-five undergraduate courses of a special nature, each one of which is an extension or amplification of material which has been introduced in the fundamental courses. At their best these special courses represent individual points of view with which the student will do well to become acquainted. But usually they represent impersonal resumés of the important work in various fields which the student is expected to copy in his notebook and to reproduce upon demand. All the evils of the lecture system are found in these courses; there is practically no encouragement for the student to develop the ability to survey a field and to form an independent judgment.

The results of this type of education for those who continue to work in chemistry are painfully evident to teachers in graduate schools and to the heads of industrial laboratories. What these men wish to see in the oncoming generation of chemists is the ability to attack singlehandedly and to master independently a phase of work which is strange and new; what they find is too often a parrot-like knowledge of the subjects which the young chemist *had* in college, and a pitiable helplessness before the new problems he is called upon to face. College training has not succeeded in freeing him of his intellectual inertia.

Although I do not here advocate the adoption of the German university system, I see as one of its advantages the fact that there are so few specialized *courses*, while so much of the student's time is spent in individual work. After about three years in the university, a student of chemistry is very much *on his own*. His reading and his independent experimental work take up most of his time.

As a means of helping the young chemist to overcome the mental inertia which will hold him back, whether he goes into graduate work or into an industrial laboratory, as a means of better preparing him for turning his hand to any problem of chemistry with which he might find himself concerned, I believe in a reorganization of the curriculum on the basis of the thesis that the student must accept the responsibility of teaching himself. The student must do his own learning. Not only is this a means of overcoming one's intellectual inertia; it is also a recognition of a fact which each one of us appreciates more profoundly as his experience grows—

one knows only so much as he has lived. Facts become a part of us not when they are sprinkled over us from the lecturer's desk, but only when we jump into them and wallow around in them.

The details of the kind of a course which I believe would accomplish the desired end and which I have called a *tutorial* course are as follows: the course should occupy a third or a fourth of the student's time for at least a year; it should consist of a study, either theoretical or experimental, of some relatively specialized branch of chemistry; the student, if doing theoretical work, should write a paper once in two weeks and read it to his instructor (tutor) at a regularly scheduled conference hour; if doing experimental work the student should make some sort of report at the conference hour; the work should be conducted by the student in such a way as to make use of his teacher as an adviser, not as a fountain of knowledge.

It will be seen at once that this course differs little from the *honors* course to be found in a number of colleges, or from the thesis work required of senior students in some other schools. If all chemistry departments offered *honors* work or required theses, there would not be the crying need which now exists for reform of the chemistry curriculum. But theses are required of chemistry students in few colleges, and in a number of schools that have attempted to introduce the *honors* course idea the departments of chemistry have not coöperated wholeheartedly. Further, the author's suggestion goes beyond the *honors* scheme in that the tutorial work is to be *required* of *all* students who specialize in chemistry.

Below is given, as a concrete example, part of the college catalog devoted to the chemistry curriculum of a department with three teachers, as the author would like to see it.

Curriculum for students intending to major in chemistry. A major consists of at least 30 semester hours' work, including a year of general chemistry, at least a half year each of analytical, organic, and physical chemistry, and at least a year's work in tutorial courses.

GENERAL CHEMISTRY—5 hours: 3 hours lecture and quiz, two laboratory periods per week. Through the year. Mr. A.

ANALYTICAL CHEMISTRY—3 hours: 1 hour lecture, two laboratory periods per week. Through the year. Mr. B.

ORGANIC CHEMISTRY—4 hours: 2 hours lecture, two laboratory periods per week. Through the year. Mr. C.

PHYSICAL CHEMISTRY—4 hours: 2 hours lecture, two laboratory periods per week. Through the year. Mr. A.

TUTORIAL COURSES—5 hours. Each course continues a half-year. Open to juniors and seniors who satisfy the instructor that they are prepared to undertake the courses chosen.

MR. A.

Theoretical—Phase Rule, Atomic Structure, Crystal Structure, Thermodynamics, Photochemistry, Catalysis, History of Chemistry, Hydrogen-Ion Determination.

Experimental—Thermochemistry, Colloids, Hydrogen-Ion Determination.

MR. B.

Theoretical—Special Problems in Industrial Chemistry.

Experimental—Water Analysis, Iron and Steel Analysis, Fertilizer and Soil Analysis, Gas Analysis, Inorganic Preparations, Fuel Chemistry.

MR. C.

Theoretical—Stereochemistry, Physiological Chemistry, Biochemistry.

Experimental—Organic Qualitative Analysis, Organic Quantitative Analysis, Dye Chemistry, Petroleum Chemistry, Food Products, Physiological Chemistry.

Certain questions which immediately arise as a result of the perusal of this scheme may be briefly answered. Will not the instructor be overburdened? In a school of 500–1500 students, with three or four members of the department, there will not be more than five or six chemistry majors per instructor from any one college class. Each man would have a half-dozen students to meet individually once in two weeks, and in addition he would have to keep himself in a position to advise the student concerning the next steps in the student's work. But, on the other hand, the teacher would be freed from the one or two special courses which he gives under the present system. In a large institution, with a great many students of chemistry, the professors will be so busy with graduate students that they can spare little time for personal advisership to undergraduates. Here the work of advising the undergraduates would have to be taken over largely by the younger instructors. Will not the student's progress be very slow in a subject which he attacks with so little guidance? To be sure his progress will be slow, but he will be preparing himself to attack more efficiently his next problem, and he will be learning well what he does learn. Why require the student to take even the so-called "fundamental" courses? There is a certain discipline and a certain language of chemistry which must be mastered by every chemist before he can make himself intelligible to other chemists, and before he can understand them. It is primarily to furnish this common ground of understanding that communal courses in the "fundamentals" should be given. Why require only a half-year of analytical, organic, and physical chemistry? To a student who is interested primarily, for example, in physical chemistry, a half-year's work in each of organic and analytical chemistry should provide a sufficient vocabulary. He should study physical chemistry for a year, preferably as a junior, and thus have his senior year for tutorial courses. Analogously, one interested in analytical or organic chemistry may devote only a half-year to each of the two courses in which he is not particularly interested.

The man who can make up his mind quickly makes up other people's minds for them. Say yes or no—seldom perhaps.—LORIMER

IMPROVEMENT OF SCIENTIFIC ABILITY THROUGH THE USE OF THE INDIVIDUAL LABORATORY EXERCISE IN CHEMISTRY[1]

RALPH E. HORTON, SEWARD PARK HIGH SCHOOL, NEW YORK CITY

The movement to scrutinize our practices in science teaching, of which the topic for the present conference is an evidence, is, no doubt, a good sign. The proposal to be made in this paper is an outgrowth of an investigation of some of these practices in one school. I have been asked to describe a method of using the chemical laboratory as a means to attain certain defined elements in the category comprehended by the term *scientific ability*.

Chemistry, in common with other sciences, has inherited a system of instruction. This system consists of several parts: some vital; some appendages; some functioning and some atrophied. Among these parts of our system may be mentioned the following:

A syllabus of topics, principles, and theories.
A textbook.
A laboratory manual of directions for experiment.
Individual laboratory exercises.
Teacher demonstration exercises.
Formal recitation periods.
Written homework.
A student's notebook.
The oral quiz.
The written examination.
Weekly, monthly, and term marks.
Measurement of teaching ability by the number passing or failing.

If we propose to improve scientific ability through the study of chemistry we may well ask which of these elements in our practice do now contribute to this aim. Have we any evidence—objective evidence, not opinion—that these cherished procedures do contribute to this aim or to any other which has been accepted as a proper goal? Science is as able to justify its practices and its objectives as any of the school subjects; but this is not sufficient for present-day curriculum investigators. If the improvement of scientific ability is accepted as a worthy goal, we need to know which elements in our practice may be utilized to assist in realizing this goal.

Psychologists tell us that scientific ability is very complex: a mixture of native physical capacities; many mental and physical habits; many conditioned reactions and many emotional attitudes. Thus, with an objective which involves numerous elements and with a system of practices which involves many others, our problem is not simple. The psychological basis of the present proposal is, that, regardless of what we may believe about *transfer of training*, the best way to be sure that pupils will learn to do anything is to give them the opportunity to practice doing this very

[1] A paper read before the Association of Science Teachers of the Middle States and Maryland, at Atlantic City, December 1, 1928.

thing. Herbert Spencer's theory that scientific ability is inherent in the subject of science and that students exposed to such subject matter would by some emanation be endowed with scientific ability, seems, somehow to fail of realization in practice. Likewise the recommendation of the Committee of Ten for individual laboratory work in science has not produced the results hoped for. With some objective evidence[2] that individual laboratory work does yield outcomes in terms of student abilities along manipulative lines, we thought it possible to utilize the laboratory period more profitably by modifying the traditional procedures. An experimental program of controlled classes instructed in the laboratory in various defined ways was carried through to test the possibility of such use of the laboratory. The outcomes of these proposed methods were measured objectively by traditional written tests, by a written test of chemical judgment and by several forms of performance tests requiring manipulation. On the basis of these data, one method, *the problem method*, gave such evidence of superiority that it has been tentatively adopted as the practice in our school.

Only the briefest description of the technic of measuring can be given here. The equivalent-groups method, checked by groups instructed by different teachers was used. The performance tests required actual doing of tasks in the laboratory and provided for objective scoring of each pupil's achievement. The "Laboratory Set-ups Test" was given to groups of 30–40 students in a fifty-minute period. Ten problematic situations involved in the regular instruction were described in such a way that they constituted a problem and not a memory exercise. For instance, one problem was, "Set up the apparatus to collect a bottle of a soluble gas, lighter than air and which can be made by heating a mixture of two powders." The individual score was the number of items done correctly. The group measurement was, of course, the mean and standard deviation from the mean, these values being compared for the various experimental groups. The "Laboratory Projects Test" was administered in the same way as the apparatus test, that is, by means of several proctors who scored each individual procedure of each individual student as fast as the students raised their hands to indicate completion. Two problems, analyzed into seventeen items, constituted the "Project Test." This test required the complete preparation and testing of each of two substances; while the other test required only the setting up of the apparatus. One of the projects, for example, was, "Set up the apparatus, prepare and test a bottle of a gas which is heavier than air, insoluble in water and can be prepared by the action of the chemicals in bottles I and II. Heat is required."

These performance tests detect differences in the abilities developed by

[2] Horton, R. E., "Does Laboratory Work Belong?" THIS JOURNAL, **5**, 1432–43 (Nov., 1928).

laboratory work and yield an objective measure of such abilities. They are imperfect instruments, to be sure, but they offer a means of evaluating methods of laboratory work heretofore lacking. In Tables I and II very significant differences are shown between the abilities resulting from the traditional laboratory method of following directions from a manual as compared with the abilities resulting from the *problem method*. The latter method in all cases appears to be greatly superior for doing this kind of a task. The statistical requirements for reliability of such comparisons are differences of three times the standard deviation of the difference. This represents 999 chances in 1000 that the true difference lies in the same direction. It is evident that reliabilities measured by 12 to 14 times the sigma of the difference exceed these requirements and must be considered very significant. It also seems fair to infer that the method which yielded the best results is superior for training in this kind of task.

TABLE I

MEAN SCORES OF THE GROUPS* FOR EACH TEST

Name of the test	Mean scores Control	Problems 20 weeks	Problems 10 weeks
Written examination	41.08	42.21	41.84
Chemical judgment	11.28	13.35	12.72
Apparatus set-ups	3.69	8.27	9.04
Chemical projects	6.07	13.67	8.75

* Data as to the number of students and controls are reported in a monograph, *Teachers College Contributions to Education*, No. 303.

TABLE II

DIFFERENCE† BETWEEN THE MEAN SCORES AND THEIR RELIABILITIES

Test	Experimental group	Difference	S. D. of Diff.	$\frac{\text{Diff.}}{\text{S. D. Diff.}}$
Written examination	Problems 20 wks.	1.13	1.39	0.81
Written examination	Problems 10 wks.	0.76	1.00	0.76
Chemical judgment	Problems 20 wks.	2.07	0.66	3.14
Chemical judgment	Problems 10 wks.	1.44	0.55	2.62
Apparatus set-ups	Problems 20 wks.	4.58	0.32	14.50
Apparatus set-ups	Problems 10 wks.	5.35	0.37	14.42
Laboratory projects	Problems 20 wks.	7.60	0.67	12.30
Laboratory projects	Problems 10 wks.	2.68	0.46	5.83

† The differences in all cases represent the number of score points by which the Mean Score of the Experimental Group exceeds the Mean Score of the Control Group.

NOTE: The measure in the last column $\left(\frac{\text{Diff.}}{\text{S. D. Diff.}}\right)$ represents the probability of the true difference being in the same direction. In a normal distribution practically all the cases would fall ± 3 sigma distance from the mean. Hence, when a difference is 3 times the S. D. of that difference, it represents *practical certainty*. Values greater than 3 are correspondingly more reliable.

The method which showed such superiority for the performance of these practical tasks has been called the *problem method*. This is neither startling in its suggested innovations nor in the manner of administration. The departure from common practice consists of the following procedures:

1. No oral or written directions are given to the students for the conduct of the experimental work.
2. The pupils plan their own experiments and devise their own methods.
3. Every laboratory exercise is proposed as a problem or perplexity to be solved by experimental evidence.
4. The method of scientific thinking after exposition adapted to the high-school level is made an aim consciously apprehended by the pupils as a habit to be acquired.
5. Illustration of chemical principles and information about them are considered as subordinate to the formation of habits of logical thinking and scientific investigation.
6. All information for which the pupils are responsible as well as all necessary patterns of manipulative technic are presented by teacher demonstration. In other words, the pupils are expected to use what they have learned in the classroom and in the demonstration by applying it to their laboratory problems.

While we have adopted the label *problem method* as best describing the plan, yet it differs from the common conception of the project method in that the problems are simple perplexities arising from the regular course in chemistry and that all pupils in a section attack the same problem by their own individual plan. Thus, neither the organization of the subject matter nor the class groups are disturbed. I am not defending the present logical organization of our sciences nor the present vogue of class instruction in public education; but both are, desirably or undesirably, a part of the *status quo*. The following of a syllabus and the maintenance of class groups, therefore, appear to be necessary. Adjusting ourselves to this situation, then, we select perplexities, or so analyze them that the data necessary to reach a satisfying answer may be experimentally gathered in a single laboratory period of fifty minutes. With longer periods and with smaller groups it is probable that more significant problems could be undertaken and more careful training in methods of scientific attack would result. This assumption remains to be verified. Our pupils are encouraged to undertake individual problems other than those proposed in class. For these, the facilities of the laboratories are made available after school.

The plan of administration is as follows: on the day preceding the laboratory period a subject for investigation is proposed by the class or by the teacher. This problem is one which has arisen in the consideration of the immediate topic and has importance and interest in connection with this unit. The problem is stated in the form of a simple question, such as, "How can we make some dry potassium nitrate?" or, "Which acid, sulfuric or hydrochloric, is better for the laboratory preparation of carbon

dioxide?" In the hands of each pupil is a guide sheet entitled, *Record of Laboratory Work*. A copy of this appears below.

DEPARTMENT OF SCIENCE

Record of Laboratory Work Name.....
Science Class..... Date.....
Subject: (Name of topic.....)

1. *Problem:* State your own perplexity in the form or *one* or *two* or *three* precise, simply worded *questions*.
2. *Hypotheses:* Briefly state one or more possible answers that occur to you after thinking the questions over. If you have more than one question in your analysis of the problem, indicate your hypothesis (guess) for the answer to each.
3. *Experimentation:* Devise (*i. e.*, make up) an experiment in which you state definitely just what you propose to do to test out your hypothesis. Number each step of your method.

   In the laboratory do these things you have thought out and record what happens, together with any measurements or other facts under the heading "Observed facts."

   a. Sketch
   b. Method
   c. "Observed facts"
4. *Conclusions:* 1. Decide by inspection of the facts whether any one of your hypotheses was correct. If you think it was, state the answer to the question.

   To appear on right hand page

   2. If the *evidence* is against your hypothesis state this as an answer to the question.
   3. Next—if your hypothesis was wrong—look at the question and the facts and make another hypothesis. Try this on another sheet and with another experiment—if you need it.
   4. Finally, make one or more statements of what use your conclusion is; or what other questions it suggests.

This constitutes a summary of the *scientific method* we are trying to lead the students to acquire as an habitual mode of attacking and solving perplexities in chemistry. A more extensive exposition of *scientific thinking* adapted to the high-school level is put in the hands of the pupils for reading and motivation. In this exposition and in the class discussions, attempt is made to show the application of this desirable habit of thinking to other daily problems—in school and out. No evidence is at hand to show that the desired transfer or spread results. Our data indicate that ability to solve chemical perplexities is measurably improved by this method of training. We can only hope it will function in other situations.

For home assignment, the pupils are directed to use this guide for writing in their notebooks their self-devised plan. Before coming to class each one is required to write (1) the *problem*, (2) a concise statement of their *guess* or *hypothesis* as to the answer (this suggests itself to them by a few minutes recall of their demonstrations and other previous ex-

periences), (3) a *method* or *plan* of experimentation to determine with apparatus and chemicals the correctness or incorrectness of this guess (this plan is detailed in numbered steps of procedure), (4) a *sketch* of the proposed apparatus is drawn in the notebook. Patterns of apparatus for general rather than specific purposes are learned after sufficient observational experience has been given by teacher demonstration.

This plan, then, as individually devised by each pupil is brought to the laboratory on the following day. With notebooks open, the pupils file past the instructor who by quick inspection of the sketch and plan decides whether it is feasible and if so the page is stamped *approved*. Each pupil then passes along to the supply table to select the apparatus he needs. Chemicals for any anticipated procedure are at the pupil's bench: others may be had by request from the laboratory assistant. It is of no importance to our purpose whether the student's guess was right or wrong, nor whether he does succeed actually in getting the right answer. His day's work is approved at the end of the period if he has been individually at work and shows in his book a record of happenings with an honest conclusion based on the facts. Thus we consistently emphasize the *method* rather than the acquiring of information. The pupils appear to enjoy their laboratory work and the teachers express increasing satisfaction with the mode of procedure and with the results.

In conclusion, it must be evident that this proposal is not a panacea for all the ills and perplexities of our science instruction. The use of the notebook, the textbook, the system of passing and failing, and the other procedures may all be profitably subjected to careful measurement, likewise, to see where, if at all, they do, or can assist in realizing our objectives. The problem method in the form just described or in any improved form is not a mold into which can be poured plastic pupils to have them come out stamped with *scientific ability*. The data seem to show that it does give specific training and practice in the formation of one alleged scientific habit. This training seems to function in solving *practically* certain perplexities in the field of chemistry, which authoritative opinion asserts is one aspect of scientific ability. If this kind of task is a worthwhile activity, as may be determined by some future curriculum study or by the judgment of specialists, then we may say, with some confidence, here is one way to teach pupils to do it.

Further details of the plan are not secret. The two features of the study to which your criticism is invited and which I have tried to very briefly describe are: (1) the technics of measurement by objective performance tests, and (2) the proposal to discontinue the use of written or other directions for laboratory work. If some of this audience would venture to try the plan with their own classes, it would be gratifying to the speaker and perhaps useful to the cause of science teaching.

A RATIONAL METHOD FOR BALANCING EXCEPTIONAL CHEMICAL EQUATIONS

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Oxidation-reduction equations which involve valence changes of more than two elements are sometimes quite difficult to balance. When two of the elements which change in valence occur in the same compound they may be considered as a unit and the total valence change of the compound may be used to determine the ratio of oxidizing to reducing agent.

In the following equation, for example, if the valences of the several elements which change are marked above them as shown, it is apparent that for each mole of copper arsenide taken three atoms of copper lose one valence unit each and one atom of arsenic gains eight valence units. The gain for each mole of copper arsenide is therefore five valence units. One mole of oxygen loses four valence units. Hence the ratio of copper arsenide to oxygen is that given in the completed equation:

$$\overset{+1\ -3}{4Cu_3As} + 6Na_2CO_2 + \overset{0}{5O_2} = \overset{0}{12Cu} + \overset{+5\ -2}{4Na_3AsO_4} + \overset{-2}{6CO_2}$$

It often happens that two of the elements which change in valence may be considered as a unit even though they do not occur in the same compound. In the following equation, for each mole of potassium permanganate taken one mole each of potassium acid sulfate and manganous sulfate is formed:

$$\overset{+7}{2KMnO_4} + \overset{+4}{6SO_2} + 2H_2O = \overset{+6}{2KHSO_4} + \overset{+2+6}{2MnSO_4} + \overset{+5}{H_2S_2O_6}$$

Each sulfur atom which enters into either of these compounds gains two valence units. Considering the permanganate and sulfate as a unit it follows that one manganese atom loses five valence units while two sulfur atoms gain two valence units each; and that the total loss for the combination is one valence unit. Each sulfur atom which forms dithionic acid gains one valence unit. Therefore, one mole of sulfur dioxide forms dithionic acid for each two moles which enter the other compounds, and the ratio of permanganate to sulfur dioxide is one to three. But sulfur occurs in multiples of two in dithionic acid, hence these numbers must be multiplied by two.

The decomposition of sodium hydrogen phosphite furnishes an interesting equation:

$$\overset{+3}{Na_2HPO_3} = \overset{+5}{Na_3PO_4} + \overset{+5}{Na_4P_2O_7} + \overset{-3}{PH_3} + H_2O$$

Each phosphorus atom which forms phosphine loses six valence units while each which enters either of the other compounds gains two valence

units. Therefore, the number of phosphorus atoms which form phosphine is to the number which form sodium phosphate and pyrophosphate as two is to six. An additional relationship must be found. In sodium hydrogen phosphite, each phosphorus atom is associated with two sodium atoms. This ratio must remain the same on the right-hand side of the equation. But in sodium phosphate there is one more sodium atom than the ratio calls for while in phosphine there are two less. Therefore, for each mole of phosphine formed two moles of sodium phosphate must be formed. But two moles of phosphine must be formed to satisfy the first ratio, hence four moles of sodium phosphate are formed. The completed equation is:

$$8Na_2HPO_3 = 4Na_3PO_4 + Na_4P_2O_7 + 2PH_3 + H_2O$$

A very pretty exercise is furnished by the equation for the reaction of potassium ferrocyanide with sulfuric acid:

$$\overset{+2\ -4+3}{K_4Fe(CN)_6} + \overset{+6}{H_2SO_4} = \overset{+6}{K_2SO_4} + \overset{+3+6}{Fe_2(SO_4)_3} + \overset{-3\ +6}{(NH_4)_2SO_4} + \overset{+4}{SO_2} + \overset{+4}{CO_2} + \overset{+2}{CO}$$

As the iron atoms appear in multiples of two on the right-hand side of the equation at least two moles of ferrocyanide must be taken. For each two moles of ferrocyanide which enter the reaction, four moles of potassium sulfate, one mole of ferric sulfate, and six moles of ammonium sulfate are formed. They require forty-eight hydrogen atoms or twenty-four moles of sulfuric acid. Thirteen sulfur atoms have already been accounted for, the rest must form eleven moles of sulfur dioxide.

Now consider the changes in valence which take place. Two iron atoms gain one unit each, twelve nitrogen atoms lose six units each and eleven sulfur atoms lose two units each, making the total net loss ninety-two units. Some carbon gains eight and some gains six units and the total gain for the twelve atoms of carbon must be ninety-two. Let x atoms gain eight. Then $12 - x$ atoms gain six and $8x + 6(12 - x) = 92$ from which $x = 10$. The completed equation follows:

$$2K_4Fe(CN)_6 + 24H_2SO_4 = 4K_2SO_4 + Fe_2(SO_4)_3 + 6(NH_4)_2SO_4 + 11SO_2 + 10CO_2 + \underset{2CO}{}$$

The valence assigned to any element in a compound actually makes little difference *as far as balancing the equation is concerned.* And the work involved in the process may often be shortened by choosing a number to represent the valence of an element which will enable it to be eliminated as a factor of change. If in the preceding equation the valence of carbon in ferrocyanide is considered as plus four, then the valence of nitrogen must be minus five, and the carbon which forms carbon dioxide exhibits no change in valence.

The changes which do occur are: two iron atoms gain one unit each,

twelve nitrogen atoms gain two units each, and eleven sulfur atoms lose two units each, making a total net gain of four units. This must be offset by the loss of two carbon atoms forming carbon monoxide.

It would be still more advantageous to consider the valence of carbon in ferrocyanide as plus two and that of the nitrogen as minus three.

A few equations do not lend themselves to the method of solution explained above. The following equation is typical of a class which requires a slightly more complicated treatment.

$$\overset{+2}{K_4Fe(CN)_6} + K_2S_2O_3 = \overset{0}{KCNS} + \overset{+6\ \ -2}{K_2SO_4} + \overset{-2}{K_2S} + FeS$$

By assigning a zero valence to sulfur in potassium sulfocyanate the cyanide is eliminated from the problem. Only sulfur changes in valence. That which forms potassium sulfocyanate loses two units; that which forms potassium or iron sulfide loses four units, and that which forms potassium sulfate gains four units.

It is evident that for every mole of potassium or iron sulfide formed, one mole of potassium sulfate must also be formed. And that for every two moles of potassium sulfocyanate formed, one mole of potassium sulfate is formed. Furthermore, six moles of potassium sulfocyanate are formed for each mole of iron sulfide.

Let d be the number of moles of iron sulfide, then $6d$ is the number of moles of potassium sulfocyanate. Let b represent the number of moles of potassium sulfate and c the number of moles of potassium sulfide. Then the gain in valence units of b atoms of sulfur in potassium sulfate is equal to the loss in valence units of $6d$ atoms in potassium sulfocyanate plus c atoms in potassium sulfide plus d atoms in iron sulfide. Expressed algebraically: $2 \times 6d + 4c + 4d = 4b$ from which $b = c + 4d$.

Some other relationship between the unknowns b, c, and d must be found. The ratio of sulfur to oxygen in potassium thiosulfate is two to three. This ratio must hold on the right-hand side of the equation as there is no other source of sulfur or oxygen. All of the oxygen from potassium thiosulfate forms potassium sulfate so that for each three moles of potassium sulfate formed there must be eight atoms of sulfur somewhere on the right-hand side of the equation. As there is one atom of sulfur in each mole of potassium sulfate, there must be five distributed among the other three compounds. Expressed algebraically:

$$6d + c + d = 5 \quad \text{when } b = 3, \quad \text{but } b = c + 4d.$$

hence $c + 7d = 5$, when $c + 4d = 3$. Solving these simultaneous equations gives $c = {}^1/_3$, $d = {}^2/_3$, and $b = {}^9/_3$ from which $c = 1$, $d = 2$, and $b = 9$. The completed equation is:

$$2K_4Fe(CN)_6 + 12K_2S_2O_3 = 12KCNS + 9K_2SO_4 + K_2S + 2FeS$$

HIGH-SCHOOL PROJECTS IN CHEMISTRY

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Much has been written and said about the so-called project method of teaching. It has seemed to the writer that this could be done successfully only by the teacher with special aptitudes or special training. The past year, however, has seen successful semester projects in chemistry by a teacher without special training in the project method.

In making up the "Minimum Requirements for Receiving Credit in Chemistry" for our department, the following item was included: *One semester paper of considerable length and detail accompanied by illustrations or exhibits.* Students thus knew and understood in advance that this paper was required and that it was important.

Getting Started.—Immediately following the Christmas holidays, the project was mentioned. The teacher announced that the report would be due near the close of the second semester. The first Monday of the second semester the projects were considered at some length. Various good papers were considered and numerous suggestions for topics were made and discussed by the class. The assignment for the following Monday was to have a tentative topic for the project and a brief paragraph telling why such topic had been chosen. It was pointed out that availability of reference material was an important consideration. This led to a search of school, city, and home libraries by the students.

At the appointed time the topics chosen were listed. It was found that several topics were strong favorites. Glass (and other forms of silica compounds) was the leader. The class had just been studying this subject and had found it of interest. Many of the girls chose to write about cosmetics. Pigments was another subject that interested several.

Although it was felt by the instructor that much duplication was undesirable, little effort was made to change the topics chosen. All the students who chose cosmetics later changed to other subjects. Several of those who first tried glass decided to change. The final list of topics chosen, together with the number of students writing on any topic, follows:

Rayon (1), Perfumes (1), Pigments (1), Glass Making (1), Dyes and Dyeing (1), Chemistry of Milk (2), Tanning of Leather (2), Petroleum Refining (3), Textile Chemistry (1), Metallurgy of Iron (1), Industrial Silicates (1), Manufacture of Sugar (2), Paints and Varnishes (2), Photographic Printing (1), Chemistry of Bread Making (1), Chemistry of Milk Products (1), Chemistry of Electric Cells (1), Soda, Baking Powder, and Yeast (1).

Every alternate day the chemistry class met for two 45-minute periods. When the class met for but one period on Friday they were asked to turn in a brief written statement of the work done on projects during the week.

Each alternate week when there was a double period on Friday, the day was given over to the term project. Activities on such days included: (1) teacher-pupil consultation; (2) library work; (3) laboratory work; (4) writing of paper; (5) preparation of exhibit.

Consultations.—In the beginning the consultations largely dealt with the location of material. Later they related to the interpretation of what had been read or done in the laboratory. Toward the close, conferences dealt with organization and presentation of the material. Such conferences enable a teacher to come in contact with students in a way impossible in routine class work.

Library Work.—Students were expected to investigate many sources of information. A daily paper was available in the science hall and was watched by some pupils. Various current magazines were available in the same way. It was, of course, necessary to point out that the reliability of information is judged by its source. The desirability of checking and corroborating evidence to as great an extent as possible was learned. The use of quotation marks and bibliographies proved a great trial both to teacher and pupils.

Except for special reasons pupils were expected to bring library books to the classroom rather than to ask to go to the library. Since the majority of the chemistry books were in the science hall rather than the library this imposed little difficulty.

Laboratory Work.—Individual laboratory work was encouraged. This was of two types, either to learn something that was in question or to demonstrate some process. Thus one boy writing about glass wanted to know whether other things could be used instead of silica. He tried, at the teacher's suggestion, some borax and found that other things will make glass but concluded after carrying the borax glass around in his pocket for some time that it was not hard enough to be satisfactory. Since most of the laboratory work was arranged by the students it was largely of a demonstrative nature. Thus several people working with paints made a number of pigments. Such demonstrations were very valuable because nearly always they involved changing from commercial processes to small laboratory processes. This in turn better enabled students to interpret their regular laboratory work and to think from laboratory work to commercial practice.

Reports.—The reports of the semester project included a consideration of what had been read, a discussion of any laboratory work which had been done, a summary, and preferably drawings or illustrations cut from printed matter and pasted in. Long quotations were omitted but short quotations were desirable if properly punctuated and credited to the author.

Photo Project.—One boy whose grade had hovered around the minimum passing grade chose photography for his project. He had a camera

and had taken some fairly good pictures. He felt when he started that he would study the whole field. This seemed a bit ambitious but he was advised to write to the Eastman Kodak Company for various of their publications. After some study he decided that he had taken too large a subject and decided to limit its scope. Finally, he concluded that printing was a more profitable study than the developing of films. His first problem then was to make a printing box. This was done and so arranged that a red light was on all the time and the white light could be switched off or on. Since completing the project, he is building a new outfit.

Then began a series of experiments with all experimental pictures saved, whether good, bad, or indifferent, to be used for reference and exhibit. This experimental work became so interesting that it interfered with his athletics.

The first experiment made with Velox was to determine length of exposure and time of development. The pictures were very poor until the right amount of time was worked out for average negatives. The second experiment was to contrast the action of flat and average negatives. These pictures were much better. This led to experiments in removing the print from the developer when it had a certain appearance rather than trying to time it. The boy says, "Personally, I prefer the method of observation during development because I have been able to obtain better results this way than by taking the length of development in seconds."

The third experiment was with a sunlight paper. Some good prints were obtained but he felt that the method was too slow. Another experiment was with Ozalid paper which he found easy to use but very unsatisfactory for anything but line drawings.

He concludes, "I find printing to be a delightful pastime as one has unlimited chances for experimenting, also one can try coloring the prints or producing sepia tones. I can save quite a sum of money by printing my own pictures. Besides there is a great feeling of satisfaction and pride in knowing that good prints have been produced by my own efforts."

Exhibits.—Each year the school has a day known as "Patrons' Day" when as many departments as desire put on exhibits. The chemistry department has always endeavored to have an exhibit. This has usually been a good deal of work. The projects solved this difficulty last year. Project reports were to be illustrated or accompanied by exhibits. Part of the class did one and part the other. Each report was on display and was something of which the student might well be proud.

In addition to the written or typewritten reports were the displays of such students as had seen fit to make them. The exhibit to accompany "Soda, Baking Powder, and Yeast" included samples of sodium bicarbonate, cream of tartar, sodium acid phosphate, alum, and starch, together with a brief statement that these were the chemicals present in baking powders.

Samples of three baking powders, one each of the chief types, were also included.

One of the boys who chose Chemistry of Milk as a topic presented samples of butter fat, lactose, albumin, casein, ash, and water as the main ingredients of milk.

A girl who wrote about textiles arranged parts of exhibits put out by cotton and silk manufacturers. In addition she gave a demonstration of tests for textiles which was of considerable interest.

The boy who studied photography made prints during the afternoon and evening. It is astonishing how few people who have cameras know anything about making pictures. This demonstration seemed to have an unique appeal to high-school students. Incidentally, the boy took orders for several dollars' worth of printing.

The students working on paints and pigments obtained a moving picture on the manufacture of white lead which was used by the entire class. In addition the same white lead concern sent samples of pots, lead buckles, white lead, acid, oil, etc., which were worked up into a good exhibit by two students. One made a drawing showing a cross-section of a filled pot in a stack. The other made a diagram showing steps and processes with ribbons leading to the appropriate samples. Three students made samples of pigments which were put together on a card titled, "Pigments Made in Class."

The petroleum project had interested several students and their displays required one whole side of the laboratory. First was a large colored diagram showing strata of rock and of oil and gas, illustrating how gas pressure forces the oil out of gushers. Next came a group of maps, the first showing the oil-producing countries of the world, the second the areas of oil production in the United States, and the third the oil fields of California. These were followed by a series of charts showing the increasing use of petroleum products. While these items may be questioned in a chemistry exhibit, they are surely important in a study of petroleum.

These preliminary exhibits were followed by a distilling apparatus used in fractionating oil. This consisted of two ordinary glass condensers joined in series with a distilling flask. This was in operation throughout the exhibit, with some one to explain it. A set of seven fractions run out in the course of the project and the original crude oil were available for inspection. The boy who did this surely understands fractional distillation. In addition he obtained from the local representative some thirty or forty samples of various products put out by the Standard Oil Company of California. These were put in oil sample bottles and a neat display rack was built for them.

Values of Chemistry Projects.—Chemistry covers such a wide field that into the introductory course in high school can be but a rapid overview of

the subject. No phase can be studied in much detail in the regular class work. The semester project seems to help solve some of the numerous difficulties met by a teacher of high-school chemistry.

1. It allows the student to pick out some interesting aspect of the subject and to study it in more detail and at greater length than is possible in the regular classroom work.

2. It enables the superior student to do a great deal of work at odd times when the remainder of the class is completing an experiment, a set of problems or a quiz. If the student is able to proceed alone he should be encouraged, if not he should be guided and assisted.

3. It works toward more correlation with other departments in the school than is usually practical otherwise. The building of a photographic printing box or a display rack can best be done in the wood shop. The lettering of signs and the making of posters offers the student a chance to use his knowledge gained in art and drawing classes. The writing of long, carefully prepared papers and reports requires the pupils' best use of principles learned in English classes.

The exhibits serve to advertise the chemistry classes. This should not be overlooked. Parents desire and have a right to know what the student is doing. Projects and exhibits afford a method of doing this in a satisfactory way. Prospective pupils may become interested. If school exhibits are to be made at some local or country fair such reports accompanied by exhibits are valuable.

Physico-Chemical Investigations upon Radium. The increased demand for radium preparations for use in the cure of certain diseases has caused attention to be directed to the supplies available from the Belgian Congo. It has apparently been overlooked that the element was first discovered by Prof. and Mme. Curie in the pitchblende deposits of Jáchymov (St. Joachimsthal) in northwest Bohemia, where the isolation of radium products has been resumed since 1920. In the *Collection of Czechoslovak Chemical Communications* (January, 1929), Prof. J. Heyrovský and S. Berezický describe the application of the dropping mercury cathode methods for determining the deposition potential of radium, which is found to be 1.718 volts. The deposition potential of the element in the presence of barium and other salts was also studied, using preparations containing amounts ranging from 14.6 per cent of radium to a preparation containing 97.3 per cent of radium chloride. It is found that the difference in the deposition potentials of the alkaline earth metals are great enough to permit of the deposition of each of them being followed in their mixtures. Traces of radium are noticeable in any amounts of calcium or strontium solutions, even in the presence of alkali metals. The deposition of radium becomes indistinguishable, however, when the ratio of barium to radium exceeds 10:1. Traces of barium are discernible in solutions of all the alkalis and alkaline earths. The application of the polarographic method with the dropping mercury cathode to the determination of the solubilities of sparingly soluble salts has also been found to give concordant and satisfactory results.—*Nature* (London), **123,** 296 (Feb. 23, 1929).

THE MEASUREMENT OF CHANGE IN VOLUME ON SOLUTION

E. ROGER WASHBURN, UNIVERSITY OF NEBRASKA, LINCOLN, NEBRASKA

The following exercise, not commonly outlined in laboratory manuals, is included in the author's list of experiments for the course in elementary physical chemistry. It offers the student training in the careful determination of the density of liquids, in the use of pipets, and at the same time gives him the opportunity of studying experimentally the phenomenon of change in volume which accompanies the mixing of certain liquids. The experiment has the advantage, if it may be called an advantage, of being easily and quickly carried through. The ordinary student should obtain fairly concordant results in one laboratory period of three or four hours.

The directions call for the preparation of a series of solutions containing the same components in different proportions. For example, the following has been found to be a convenient series. (1) 10 cc. methyl alcohol, 90 cc. water, (2) 30 cc. alcohol, 70 cc. water, (3) 50 cc. alcohol, 50 cc. water, (4) 70 cc. alcohol, 30 cc. water, (5) 90 cc. alcohol, 10 cc. water. Technical methyl alcohol (methanol) may be used. These volumes are conveniently and accurately measured with pipets, and the solutions may be prepared and kept in stoppered flasks or bottles. A visual demonstration of the volume change may be had by mixing the liquids in a 100 cc. volumetric flask having several gradations on the neck. The student should notice the relative temperature changes which accompany the mixing. The solutions are then given time to come to room temperature, or, if desired, to the temperature of a thermostat.

Meanwhile the densities of the alcohol and the water may be determined, the temperature at which this is done should be that at which the solutions will be when their densities are measured. For these measurements use may be made of any of the common methods for determining the density or specific gravity of liquids. The pycnometer method permits great accuracy but is relatively slow. The author has usually assigned the specific gravity balance, either of the Mohr-Westphal type or of the ordinary balance or chainomatic type. Careful workers with good instruments and a little practice can reproduce density determinations to within a few units in the fourth decimal place. Short range, carefully graduated hydrometers might also be used.

The change in volume is calculated from the original volumes and the measured densities. Several slightly different methods of calculation are available. Some of these will be illustrated from actual observations on mixture number (3) of the above series. In forming this solution 50 cc. of methyl alcohol are mixed with 50 cc. of water.

(1) Percentage contraction calculated from change in density.

0.9973 g./cc. Density of water.
0.7894 g./cc. Density of alcohol.
0.9241 g./cc. Density of mixture.
$50 \times 0.9973 = 49.8650$ g. Wt. of water.
$50 \times 0.7894 = 39.4700$ g. Wt. of alcohol.

$49.8650 + 39.4700 = 89.3350$ g. Wt. of mixture.
$89.3350 \div 100 = 0.89335$ g./cc. Density of mixture if there had been no contraction.
$0.9241 - 0.89335 = 0.03075$ g./cc. Increase in density.
$0.0375 \times 100 \div 0.9241 = 3.32\%$. Percentage contraction.

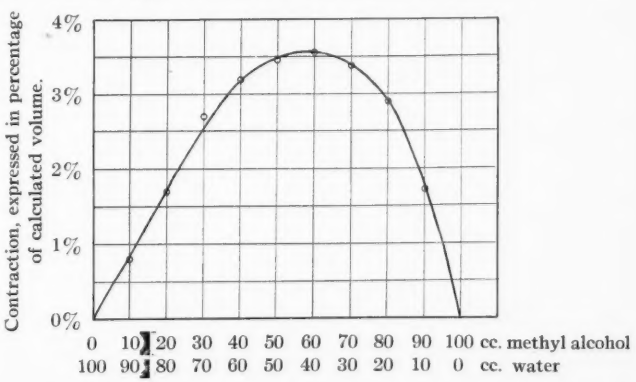
(2) Calculated from change in volume.

$89.3350 \div 0.9241 = 96.672$ cc. Volume of mixture. If there had been no contraction the volume would have been 100 cc. $100 - 96.672 = 3.32$ cc. or 3.32%.

(3) Calculated on the basis of specific volume.

$100 \div 89.3350 = 1.1193$ cc./g. Specific volume if there had been no contraction.
$1 \div 0.9241 = 1.0821$ cc./g. Specific vol. of solution.
$1.1193 - 1.0821 = 0.0372$ cc./g. Contraction.
$0.0372 \times 100 \div 1.1193 = 3.32\%$.

The following graph, constructed from a typical student report, will serve to show the type of results which may be obtained.


Contraction, expressed in percentage of calculated volume.
4%
3%
2%
1%
0%
0 10 20 30 40 50 60 70 80 90 100 cc. methyl alcohol
100 90 80 70 60 50 40 30 20 10 0 cc. water

Other pairs of liquids may be studied in place of the one described. Acetone–chloroform, ether–chloroform, ethyl acetate–water, are among those which suffer a contraction in volume on mixing. Acetone–carbon disulfide, methyl alcohol–carbon disulfide, show an expansion on mixing. Certain pairs show an expansion when the percentage of one component is high, and a contraction when the percentage of the other component is high. Our students have found this to be the case with methyl alcohol–benzene

mixtures; these solutions seem to show an expansion when the amount of benzene is equal to or greater than the amount of alcohol, but when the alcohol is greatly in excess a small contraction is observed.

The extent to which the theory dealing with this phenomenon is presented will depend upon the previous training of the students concerned. In elementary classes it will probably suffice to call attention to the fact that a positive heat of solution or of mixing is usually accompanied by a contraction in volume; while a negative heat of solution accompanies an expansion of volume. In an ideal solution (one which obeys Raoult's law) there is no heat of solution and no volume change. The nearer a solution is to being an ideal solution the smaller will be the volume change and the less will be the heat of solution. J. H. Hildebrand[1] gives a more nearly complete discussion of the above relationships and several references to the literature.

[1] "Solubility," J. H. Hildebrand, A. C. S. Monograph, Chemical Catalog Co., New York, 59–68 (1924).

Cause of Cancer Unknown Despite Many Theories. In spite of much research and many theories nothing is yet known of the cause of cancer, if it has a single cause, Dr. Shields Warren, of the Palmer Memorial Hospital, told his audience at a recent Harvard Medical School public lecture.

"While there is no one accepted cause of cancer, there are certain theories that are useful as working hypotheses," said Dr. Warren.

The reported discoveries, from time to time, of a parasite as a cause of cancer have raised hope. Among these Dr. Warren mentioned the work of Dr. Gye in England which unfortunately was not confirmed.

Many theories that special foods or substances cause cancer have been raised. Civilization has been blamed as a cause of this disease. But all of these theories have proved untenable.

The theory of chronic irritation covers many of the cancers that occur in human beings, but it is to a certain extent a superficial explanation, Dr. Warren declared. Prolonged chronic irritation of tissues stimulates cell growth and brings about unknown changes in the tissues which favor the development of cancer. Many types of chronic irritation do not go on to develop cancer, but many cases of cancer may be traced to long standing irritation.

Heredity has been considered a cause of cancer. Proof of this theory has ranged from examples of so-called cancer families or cancer villages to the painstaking work of Dr. Maude Slye. Dr. Slye proved by very careful and extensive experiments that in mice there is a hereditary predisposition to cancer, but it is questionable as to whether her findings are applicable to human beings, Dr. Warren explained. The so-called cancer villages are usually found to be inhabited largely by older people among whom the prevalence of cancer is always greater, no matter where they live.

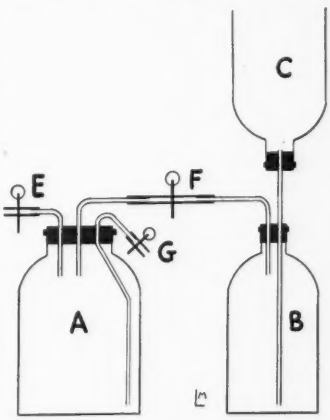
"Certainly we are safe in saying that at the present time heredity is not considered of importance as a cause of cancer," Dr. Warren declared. While the cause of cancer is still unknown, enough facts are known about cancer to make its behavior less incomprehensible and its treatment more hopeful."—*Science Service*

A SIMPLIFIED GAS GENERATOR

GREGG M. EVANS, YANKTON COLLEGE, YANKTON, SOUTH DAKOTA

While no particular originality is claimed for the gas generator shown herewith, it is believed that it *has* been reduced about to the utmost in simplicity of requirements for its assembly. Only apparatus to be found in any laboratory is necessary.

The container A holds the solid reagent. For this a wide-mouthed bottle or jar is desirable in order that as much as possible of the labor of breaking up large lumps of hard materials such as ferrous sulfide may be avoided. For a generator in use in this laboratory a five pound sodium hydroxide bottle was used for A, and for B and C, which serve as gas and liquid reagent reservoirs, the ordinary $2^1/_2$ liter acid bottles. Either pinch or screw clamps may be used at E, F, and G. For C the bottom of the bottle is cut off with a hot wire cutter[1] or if one is not available a file scratch around the bottle and application of a red hot glass rod is usually successful. Stoppers should be wired in and may be made gas tight with stopcock grease or paraffin. Rubber connecting tubes should be wired on. If the tube F be made in one piece and extend an inch or so into B, and paraffin be melted into C, even concentrated sulfuric acid may be used as the liquid reagent. Stopcocks may be substituted for one or more of the pinch cocks, and a simple spray nozzle may be blown on the delivery end of F, but these are not essential.



To use, put the solid reagent into A, and with E and F open, pour the liquid into C until it runs into A. Thereafter, with F left open, action is automatic as gas is used from E. To remove used liquid, close F and allow the gas pressure to force it out through G. The bottles, if not too large, may be supported by ordinary rings and clamps and assembled on a single ring stand.

This type of generator is very economical, since the reserve liquid in B and C is not diluted, and the use of the bottle B as a gas reservoir allows the complete utilization of reagents during idle periods without loss of gas by bubbling back through the acid container. The size of the apparatus can be varied widely to conform to requirements, and since the cost is low, as many as needed may be made available.

[1] See, for example, Baker and Haldeman, THIS JOURNAL, **5**, 1289 (Oct., 1928).

THE COLUMBUS MEETING

REPORT OF THE SECRETARY OF THE DIVISION OF CHEMICAL EDUCATION

Two half-day sessions were devoted to miscellaneous papers and two to the Symposium on Lecture Experimentation, in accordance with the detailed announcement which appeared on pages 736–7 of the April JOURNAL. Attendance never fell below 100 and exceeded 600 Wednesday morning when Dr. Langmuir, president of the American Chemical Society, presented a talking-movie experimental lecture on "Oil Films on Water."

Dr. Langmuir's lecture demonstrated convincingly the immense value of this new type of scientific lecture and his audience was enthusiastic in its approval of his epochal experiment. The film was introduced and supplemented at intervals by Dr. Langmuir in person.

At noon, May 1st, the Division was host at luncheon to 35 high-school teachers of chemistry. At the close Chairman McPherson introduced President Langmuir, Secretary Parsons, Neil E. Gordon, and William W. Buffum. Dr. Gordon and Mr. Buffum spoke briefly concerning the editorial policy and the business management, respectively, of the JOURNAL OF CHEMICAL EDUCATION.

In connection with the Divisional program, thirteen high-school and college and nine industrial exhibits were displayed in two of the larger laboratories. They attracted such favorable comment that the experiment will be repeated at the Minneapolis meeting, September 9th–13th.

A delightful feature of the program was a visit during the afternoon of May 2nd to the Ohio Wesleyan campus. Transportation was furnished by members of the Wesleyan chemistry staff, who also personally conducted the party through their recently remodeled building. After a complimentary dinner the party was driven back to Columbus, unanimous in their appreciation of the hospitality of Professor H. F. Lewis and his associates.

The Editors of the JOURNAL OF CHEMICAL EDUCATION met at 5 P.M., April 30th, to discuss the problems and policies of the JOURNAL. Dr. Neil E. Gordon, *Editor-in-Chief*, presided.

Present: Roger W. Allen, R. A. Baker, F. E. Brown, William W. Buffum, *Business Manager*, Friend Clark, F. B. Dains, Wm. Foster, Harry N. Holmes, B. S. Hopkins, Louis C. Jordy, Theodore D. Kelsey, T. R. Leigh (substituting for A. P. Black), R. N. Maxson, R. K. McAlpine, Wm. McPherson, Lyman C. Newell, W. F. Rudd, Wilhelm Segerblom, J. N. Swan, A. P. Sy, G. H. Whiteford.

The Executive Committee of the Division met for several hours during the first two days of the convention and on the morning of May 1st the Senate convened for two hours to consider reports from the various com-

mittees. At the close of the last session Thursday morning, May 2nd, the Division held a short business meeting.

Minutes of the Meetings of the Executive Committee

Present: Wm. McPherson (*chairman*), R. A. Baker, Neil E. Gordon, M. V. McGill, R. M. Parr, Wm. Segerblom, and, by invitation, William W. Buffum, J. E. Day, and L. C. Newell.

(1) Neil E. Gordon, *Editor-in-Chief*, reported upon the status of and plans for the JOURNAL OF CHEMICAL EDUCATION. It was voted to authorize the editor to publish at such time during 1929 as he may deem feasible, two successive issues of the JOURNAL under one cover, with the double caption of both month names in order to enable the JOURNAL to appear thenceforth on or before the first of the month designated on the cover.

(2) A preliminary report of the *Committee on Revision of the Constitution and By-Laws* was presented by L. C. Newell, *chairman*, and was discussed at length. The committee was requested to prepare the revision for presentation at the forthcoming business meeting of the Division.

(3) Voted that a committee be appointed to consider the advisability of constituting a committee of the Division on *Library Equipment*. Referred by Chairman McPherson to the *Committee on Outstanding Problems* (W. Segerblom, *chairman*).

(4) Voted that Dr. James Kendall's request with reference to the distribution of Alembic Club Reprints in this country be referred to the History of Chemistry Division for recommendation.

(5) The personnel and work of the committees of the Division were reviewed at length.

(6) Voted that the Secretary be authorized to employ such secretarial assistance as may be necessary to conduct the affairs of the Senate and Division.

(7) Voted that the *Committee on Revision of the Constitution and By-Laws* be asked to consider and report upon the duties and organization of the Senate and upon its relation to the Division of Chemical Education.

(8) Voted to refer to the *Committee on Outstanding Problems* (W. Segerblom, *chairman*) the question of the appointment of a committee on "Labels."

Minutes of the Senate Meeting, Pomerene Hall, 8 A.M., May 1st

Present: Wm. McPherson (*chairman*); *Ark.*, Harrison Hale; *Colo.*, G. H. Whiteford; *Conn.*, E. M. Shelton; *Ill.*, H. W. Garnett, Rosalie M. Parr; *Ind.*, M. G. Mellon; *Ky.*, R. M. Maxson, V. J. Payne (proxy for Marie Borries); *Md.*, Neil E. Gordon, E. Emmet Reid; *Miss.*, J. N. Swan; *Mo.*, Geo. F. Weida (proxy for W. E. Howe); *Mont.*, O. E. Sheppard; *N. H.*, Wilhelm Segerblom; *N. Y.*, R. A. Baker; *Ohio*, W. C. Gangloff, M. V. McGill, Wm. McPherson; *Okla.*, Otto M. Smith; *Ore.*, John Fulton; *Pa.*, F. R. Alexander, W. E. Coon; *S. Dak.*, J. H. Jensen; *W. Va.*, F. E. Clark.

(1) Harrison Hale, *chairman*, reported that the *Committee on Women's Club Study Course in Chemistry* has been unable to gain the coöperation of the General Federation of Women's Clubs. His committee was requested to prepare for publication the outline upon which it has been working.

(2) J. H. Jensen, *chairman*, reported for the *Committee on Minimum Equipment for Teaching High-School Chemistry*. He was authorized to compile, mimeograph, and distribute to the senate a preliminary report.

(3) H. A. Carpenter, *chairman* of the *Committee on Aids to Visual Chemistry Instruction*, asked by letter to be relieved of duty on this committee in order to devote full time as chairman of the *Committee on Major Topics*. His request was granted and M. V. McGill was appointed chairman in his place with instructions to make recommendations concerning the personnel of the committee and the scope of its work.

(4) In the absence of the chairman, R. M. Parr reported for the *Committee on Order of Presentation of Laboratory and Recitation Work*. The committee was continued and was authorized to prepare and distribute such mimeographed material as will be necessary in collecting data for a report.

(5) H. A. Carpenter, *chairman*, reported by letter for the *Committee on Organization of Elementary Chemistry around a Few Major Units*. A local committee has completed a preliminary study in the city of Rochester and is prepared to make specific recommendations to the national committee. The report was accepted and the committee continued.

(6) In the absence of the chairman, John Fulton reported for the *Committee on Professional Spirit among High-School Chemistry Teachers as a Group*. The report was accepted and appears on page 1157. The committee was continued.

(7) A. J. Currier, *chairman*, reported by letter for the *Committee on Preparation of High-School Teachers*. The report was accepted and appears on page 1156. The committee was continued.

(8) Allen Rogers, *chairman*, presented by letter outlines of several problems to engage the recently appointed *Committee on Chemical Education of the Non-Collegiate Type*. The report was accepted and the committee continued.

(9) Mr. Buffum, *business manager*, was present by invitation to discuss ways and means of reaching more effectively the teachers of chemistry. It was voted that a survey be made by the local organizations in their respective areas to determine which high schools are offering chemistry instruction. The question of appointing a special committee was referred to the *Committee on Outstanding Problems* (W. Segerblom, *chairman*).

Minutes of the Business Meeting of the Division of Chemical Education Chemistry Building, 11:30 A.M., May 2

WM. MCPHERSON, *Presiding*

(1) The secretary reported the deliberations of the Executive Committee and the Senate.

(2) Voted to appoint a committee to draft resolutions expressing our appreciation to the Ohio Section for their entertainment. (Rosalie M. Parr designated by *Chairman* McPherson.)

(3) Voted that the Division accept the report of the *Committee on Revision of the Constitution and By-Laws*, consisting of L. C. Newell, Wm. Segerblom, and R. A. Baker.

R. A. BAKER, *Secretary*

THE MINNEAPOLIS MEETING

(Tear Out and Mail)

I plan to attend the Minneapolis meeting of the American Chemical Society.

I do (not) wish to present a paper before the Division of Chemical Education.

Title.....

.....

Time required.....minutes

Lantern?.....

Moving Picture Projector?

I do (not) wish to receive information concerning rooming and camping facilities near the University of Minnesota.

.....

(Name)

.....

(Address)

Note: Early notice from authors will enable the *Secretary* to plan the program more efficiently. Abstracts should be sent as soon as possible for the same reason. **To appear on the Minneapolis program the completed paper as well as the abstract in duplicate must reach the *Secretary* not later than August 3rd.** In general, not longer than 20 minutes will be available for each paper.

Mail to

R. A. BAKER, *Secretary*, Division of Chemical Education

Syracuse University, Syracuse, N. Y.

YOUR AFTERSELF

A Commencement Message for All Youth

DAVID STARR JORDAN

YOUR first duty in life is toward your afterself. So live that the man you ought to be may, in his time, be possible, be actual. Far away in the years he is waiting his turn. His body, his brain, his soul, are in your boyish hands. He cannot help himself. What will you leave for him? Will it be a brain unspoiled by lust or dissipation; a mind trained to think and act; a nervous system true as a dial in its response to the truth about you? Will you, Boy, let him come as a man among men in his time? Or will you throw away his inheritance before he has had the chance to touch it? Will you turn over to him a brain distorted, a mind diseased, a will untrained to action, a spinal cord grown through and through with "the devil-grass, wild oats?" Will you let him come and take your place, gaining through your experience, happy in your friendships, hallowed through your joys, building on them his own? Or will you fling it all away, decreeing, wanton-like, that the man you might have been shall never be? This is your problem in life—the problem which is vastly more to you than any or all others. How will you meet it, as a man or as a fool? It comes before you today and every day, and the hour of your choice is the crisis in your destiny!—(*J. Nat. Educ. Assoc.*)

STUDENTS' EXHIBIT AT COLUMBUS MEETING, AMERICAN CHEMICAL SOCIETY*

MARTIN V. MCGILL, LORAIN HIGH SCHOOL, LORAIN, OHIO

The first exhibit of students' work at an American Chemical Society meeting was a decided success. Though not large, it was inspiring enough to warrant repetition. The exhibit was the happy idea of Charles H. Stone, chemistry instructor at English High School, Boston, Massachusetts, who, following the Swampscott meeting in September, 1928, suggested to the Executive Committee of the Division of Chemical Education the advisability of holding an exhibit of students' work as a feature of the Division meeting. The idea found favor at once, and Dr. Jesse E. Day, Ohio State University, and assistant secretary of the Division, was asked to take charge. No special attempt was made to secure exhibits, except through announcements in chemical educational journals.

The students' work was on display in the general chemistry laboratory, adjoining the room in which meetings of the Division of Chemical Education were held. Over one-half of the available space in the laboratory was used, and the majority of the exhibits were mounted on large slabs of wallboard, arranged on a framework on laboratory tables.

Any teacher who will look over the list of exhibits will find many suggestions for extra credit and regular class work. Also, many teachers will find that they are doing worthwhile things as a part of their regular work, which they do not find listed here. For the benefit of fellow teachers, it is hoped that all teachers of chemistry will make, from time to time, definite contributions to this new phase of American Chemical Society meetings.

The following is a tabulated list of exhibits by schools. In some few cases, names of students were missing from a piece of work, and where a project involved a large group, names of individuals were not listed. If any work has been overlooked, it has not been intentional, and each student, whose exhibit was on display, can feel that he or she has made a definite contribution to chemical education. Thanks of the Division should also go to Dr. Jesse E. Day and his staff of helpers for mounting and arranging the display.

Student Exhibits and Exhibitors at American Chemical Society Meeting, Columbus, Ohio, April 29–May 2, 1929

ENGLISH HIGH SCHOOL, BOSTON, MASSACHUSETTS (CHARLES H. STONE AND W. F. DOWNEY, *instructors*)

Drawings

Distillation; preparation of oxygen and hydrogen; bleaching; electrolysis; Kipp generator; Lavoisier's experiment (*Group Projects*)

* Report of the Committee on Aids to Visual Chemical Instruction.

Display Boards
Salts, oxides, dyes, rubber, metal, and pigments (*Group Projects*); medical chemicals (*M. Neuman*); paint (*Walter Smith*); matches (*Ostron and McDonald*); lead (*Rotman*); copper (*Goldblatt, Gaffer*); iron (*H. B. Hyat, F. Cahaly*); etching (*Saul Rice, Maurice Rubin*); silvering (*H. W. Fogel, Gaffer, Smith, Feenberg*); a group of tests (*Group Project*)

Exhibits
Paint pigments (*Francis Wagner*); Bakelite (*Stone*); prepared salts and dyes (*Group Project*)

MCKINLEY HIGH SCHOOL, CANTON, OHIO (L. H. BOOHER AND M. HEINRICHS, *instructors*)

Display Boards
Coal products (*E. Campbell*); products of petroleum (*A. Price*); soap (*F. Melchior*); alloys (*E. Soffel*); radium (*A. S. Priddey*)

Pamphlets
Petroleum refining; abrasives; life of Dalton (*W. Benson, Mildred Cramer*); lead (*Orlando C. Horn*); gold (*V. E. Heacock*); hydrochloric acid (*H. Ebinger*); poison gases (*E. Burdge*); aviation (*Mary E. Slumske*); water (*D. Unkefer*)

Sketch
(*I. Schumacher*)

Posters
Balanced diet (*Mary McKinney*); steel (*James Shrake*)

Flow Sheet
Solvay process (*E. George*)

Map
Chemical Chart of City of Canton (*Robert Niederhauser*)

Models
Electroplating (*H. Obermiller*); Pyrene fire extinguisher (*Cecil Phiel*); G. M. V. box (*Louis Zuber*)

Display Sheets
Removal of stains (*D. Robinson*); mordant dyeing (*N. Worster*)

Exhibits
Rats, showing effect of vitamins (*Virginia Crouse*)

WEST HIGH SCHOOL, CLEVELAND, OHIO (H. W. BAKER, *instructor*)

Poster
Feeding the family (*C. Cuszito, E. Blocher*)

Map
U. S. mineral districts (*Frank Staral*)

Outline
Qualitative analysis (*John Szucs*)

Exhibits
Colloidal preparations (*R. W. Richman*); sodium silicate crystals (*Paul Deimke*)

EAST HIGH SCHOOL, COLUMBUS, OHIO (R. W. COLLINS, *instructor*)

Model
Set-up for preparation of nitric acid, Birkeland-Eyde Process (*Robert Ebinger, Norman Lakin, Andrew Leist*)

FOSTORIA HIGH SCHOOL, FOSTORIA, OHIO (J. G. STEED, *instructor*)

Drawings and Display Boards
Destructive distillation of wood (*F. Vosberg, K. Gregory, H. Flechtner, G. Fling, E. Curtis*)

WESTERN RESERVE ACADEMY, HUDSON, OHIO (HOWARD WILLIAMS, *instructor*)

Model
Set-up of a model coke plant [apparatus illustrated in THIS JOURNAL, **6**, 745–52 (April, 1929)] (*Leon Hodgkins, Elliot Stauffer, Leland Morse, Bill Manley, Charles Meyers*)

CURRY DISTRICT HIGH SCHOOL, HURRICANE, WEST VIRGINIA

Pamphlets
Coal tar products and coal (*Ellmond Tallman*)

Display Boards
Products from coal, coal tar by-products (*Group Projects*)

LAKEWOOD HIGH SCHOOL, LAKEWOOD, OHIO (RUFUS D. REED, GLENN T. BORUFF, CHARLES KLUCKHOLN, T. P. GIES, *instructors*)

Posters
Blast furnace; the cloud; liquid soap (*Lois Williams*); metric system (*J. S. and W. H. Bates*); iron and steel manufacture, diagram of shell (*Jack Nixon*)

Pamphlets
X-ray (*J. B. Owen, Charles McCartney*); synthetic gems (*Mary Snyder*); perfumes (*B. E. Evans*); diamonds (*Raymond Becker*); the atom (*Claude Sympson, Lloyd Crosser*); glass (*Helen Gilmore, Nanette Willse, Theodore Weideman*); Pasteur (*Wm. Terrell, Donald Carmichael*); Mendel (*Stephen Horvath*); color photography (*Thomas Bradley*); matches (*Ruth Brannon, Miriam Terrell*); modern development of chemistry (*G. L. Elgin*); mica (*Phyllis Grothe*); Fluorin-Henri Moissan, a translation from French (*Robert H.*

Gammel); salt (*Robert Smith, Paul Wilkinson*); relation of chemistry to everyday life (*Ralph Hart*); paper (*Robert Darte*); Moissan (*G. M. Shauver*); explosives (*Blanche Mankosky*); steel industry (*Ruth Beard*); chemistry of foods (*Helen King*); photography (*Betty Blaisdell*)

Display Boards
From ore to wire (*T. W. Pheneger*); salt (*S. Sonnefield*); Everready batteries (*Ida Darling*); rayon

Graphs
Melting point of elements (*J. Reyburn*); boiling point of elements

Charts
Salt; uses of salt (*Ruth Mann*); chemical elements (*Ruth Harte*); coal (*M. Torril and D. Schulte*)

Maps
Minerals of Mexico; raw materials in U. S. (*Jean Duff*); mineral resources of South America (*Joseph Horance*)

Drawings
Lead chamber process (*R. Bruce, L. T. McCroden*); blast furnace (*S. Sonnefield*); table of halogens (*Mabel Severance, Elsa Weitzman*)

Exhibits
Etching by hydrofluoric acid (*Marjorie Hoeller*); colorimeter for pH control (*Ralph Au*); development of Underwood cell (*Ronald Underwood*); cell of storage battery (*John Wilson*)

Paintings
Alchemist; explosibility of hydrogen; non-flammability of helium

CENTRAL HIGH SCHOOL, LIMA, OHIO (R. W. EDMISTON, *instructor*)

Photographs
School exhibits

Drawings
Blast furnace (*Carl Baumberger*); gas works (*Robert Leech*); coal gas plant (*Raymond W. Snook*); gravity and Daniel cell (*James McKee*)

Posters
Metallurgy, refining (*Robert Jones*)

Charts
Compounds of limestone (*Emil Chiles*); acids and salts (*Virgil Roush*); color tests (*William Roberts*)

LORAIN HIGH SCHOOL, LORAIN, OHIO (L. W. SMITH, M. V. MCGILL, *instructors*)

Model
Periodic chart, spiral system, according to Harkins (*John Glorioso*)

Charts
Nitric acid tree (*Edwin Schmitkons*); nitrogen tree (*Ralph Glading*); calorie changes, ice to steam (*Burch Seneff*)

Diagram and Exhibits
Diagram of a steel plant lay-out, with exhibits of raw products and finished products, including by-product coke plant (*Donald Hicok*)

ATHENS COLLEGE, ATHENS, GEORGIA (ALICE HEAP, *instructor*)

Photographs
Chemical exhibits held at college

OHIO STATE UNIVERSITY, COLUMBUS, OHIO (JESSE E. DAY, *instructor*)

Graphs, Flow Sheets, Models
26 graphs showing periodic table, based on atomic weights; 13 flow sheets, potassium compounds; 20 atomic models (*Freshman Chemistry Class Projects*)

SOUTH DAKOTA STATE COLLEGE, BROOKINGS, SOUTH DAKOTA (Mr. Farley, *instructor*)

Atomic Model Structure Drawings
Explanation of periodicity of the lighter elements by means of the Lewis-Langmuir octet theory (*Charles A. Rund, G. C. Scherven, B. Rosendal, G. Schultz*)

Commercial Exhibits

NAME OF EXHIBITOR	BUSINESS ADDRESS	TYPE OF EXHIBIT
Wm. Ainsworth & Sons, Inc.	Denver, Colo.	Precision balances
Central Scientific Co.	Chicago, Ill.	Scientific apparatus
Chemical Rubber Co.	Cleveland, Ohio	Chemical apparatus and Handbook of Physics and Chemistry
Colloid Chemical Co.	Washington, D. C.	Pure water still
Hoke, Inc.	New York City	Devices for control of compressed gases; oxygen torches
Kauffman-Lattimer Co.	Columbus, Ohio	Chemicals and laboratory apparatus
Smith & Smith	Akron, Ohio	Reference service, translating, abstracting, and searching
The Thermal Syndicate, Ltd.	Brooklyn, N. Y.	Vitreosil products

HOW ARE TEACHERS BEING TRAINED IN COLLEGE FOR TEACHING HIGH-SCHOOL CHEMISTRY? II[1]

CURRICULUM REQUIREMENTS IN THE VARIOUS STATES

In the discussion of the first report of this committee,[2] which was presented at the St. Louis meeting of the American Chemical Society (April, 1928), Professor Frank Wade pointed out the wide discrepancy in the requirements for the training of chemistry teachers in the various states. It seemed desirable that this problem should be carefully studied. The committee has done this and submits the following results of their investigation.

Requests were sent to the educational department of the forty-nine states and territories of the United States, asking for information concerning requirements for chemistry teachers in the public schools of each state. Replies have been received from forty-four states. Connecticut, Louisiana, Michigan, New Mexico, and South Carolina have not sent information. The departments in Alabama and Oklahoma are in the process of revising their requirements. Fourteen[3] of the forty-four states have definite subject matter, other than in education, required for certification—such as eighteen hours in a major subject (chemistry) and ten hours in a minor subject, or, in other cases, thirty-six hours of science. The certificate is then granted for the special branch or branches of teaching. The remainder of the states (thirty) or nearly seventy per cent grant a blanket certificate which entitles the holder to teach any subject in the high schools of the state. Many of these states require a major and minor or a major but do not certify in that subject so that the teachers may teach any subject. This situation, in the opinion of the committee, is an extremely unsatisfactory one and calls for modification.

At least twenty-three[4] require practice teaching or successful teaching for a given period before a *permanent* certificate is issued. About ten require practice teaching before any certificate is granted. Twenty-eight states require courses in education. In many cases, work in methods courses satisfies part of the education requirements although such work is not usually compulsory.

[1] Committee Report submitted to the Senate of Chemical Education at Columbus, Ohio, May 1, 1929.

[2] THIS JOURNAL, **5**, 743–7 (June, 1928).

[3] Florida, Georgia, Indiana, Maryland, Massachusetts, Mississippi (beginning 1928–29), New Jersey, North Carolina (after 1931), North Dakota, Pennsylvania, Tennessee, Utah (as far as possible), Virginia, West Virginia.

[4] Arizona, California, Colorado, Delaware, Indiana, Kentucky, Maine, Maryland, Minnesota, Mississippi, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Dakota, Oregon, Ohio, Pennsylvania, Rhood Island, South Dakota, Utah, Vermont.

The state department bulletins indicate that, in general, the requirements in educational subjects are much more carefully worked out and standardized than are the requirements in chemistry or other science. This constitutes a serious defect in the interest of effective teaching of chemistry. A desirable sequence of courses was discussed in the first report. The committee feels that the minimum requirement in chemistry subjects should be:

General Chemistry	5 hours*
Qualitative Analysis	5 hours*
Quantitative Analysis	5 hours*
Organic Chemistry	3 hours*
Methods Course	2 hours*
Total	20 hours

* Five hours weekly of recitation or its equivalent in practice per semester is understood.

In addition to the major courses listed above it is highly desirable to include a course in physical chemistry and one in advanced inorganic chemistry. The minor subject should be, in all cases, some definitely related science such as physics, biology, or mathematics.

The wide diversity in the quality of our instruction in high-school chemistry, in the opinion of the committee, is largely due to the lack of adequate requirements for certification of chemistry teachers in many of our states. It is hoped that this investigation may be of value in the process of improving this unsatisfactory situation.

A. J. CURRIER, *Chairman*
HENRIETTA HAYDEN
N. HENRY BLACK
A. E. MCKINNEY

THE PROFESSIONAL SPIRIT AMONG HIGH-SCHOOL CHEMISTRY TEACHERS. II[1,2]

The problem of arousing a professional spirit among high-school teachers of chemistry might well begin at the beginning; let only those teachers be selected for high-school chemistry instruction who are primarily interested in chemistry. This is a much easier task than trying to make an enthusiastic teacher of chemistry out of some one who has a minimum knowledge of chemistry—no matter how well acquainted with the method of teaching he or she may be.

[1] Committee Report submitted to the Senate of Chemical Education at Columbus, Ohio, May 1, 1929.

[2] See THIS JOURNAL, 5, 747–9 (June, 1928).

Farseeing people are establishing scholarships in the new department of chemical education located in the chemical department of The Johns Hopkins University for those primarily interested in chemistry. Would that many places were established where those thus interested might become well grounded in chemistry, understand its relation to an evolving civilization, and skilled in methods of how to teach it.

Dr. Segerblom's committee to outline five leading problems in chemical education assigned important work to the committee on "How are teachers being prepared in college for teaching chemistry in high schools?" In addition thereto the question might well be raised, "Upon what basis are teachers of high-school chemistry selected?" The Division of Chemical Education has been doing important work on what chemistry is and how it shall be taught in high schools. Is by whom it shall be taught less important?

The problem of interesting the great group of high-school teachers of chemistry who are well grounded in the fundamentals of that subject is not nearly so difficult a task. The following suggestions will be of value in arousing a professional spirit among the two classes of high-school teachers previously mentioned.

Let every local section of the American Chemical Society plan at least one meeting a year which shall be of special concern to high-school teachers of chemistry—let it be chemical education night. The interest of these local sections in the chemistry departments of high schools in their respective areas would deepen the interest of teachers in their work and in turn the student body and the community. Members of a local section of the American Chemical Society interviewed a city superintendent of schools in their section in regard to a well-equipped chemical laboratory in a new high school. This school now possesses what every other high school should have, namely, good equipment for the instruction of chemistry. There are other matters related to chemistry in the high schools wherein these local sections could prove helpful.

There are thousands of high-school teachers of chemistry who do not belong to the American Chemical Society, or any organization of chemistry teachers, and neither do they subscribe to the JOURNAL OF CHEMICAL EDUCATION, yet to be a member of these organizations and a reader of THIS JOURNAL are necessary in obtaining up-to-date chemical knowledge, improved methods of teaching it, and in the maintenance of that spirit which is essential to the successful teaching of chemistry.

Furthermore, the college teacher of chemistry does much to strengthen the professional spirit of high-school teachers of chemistry when he gives an encouraging word and a sympathetic hand to help to improve the quality of chemical work done in high school. Good chemical work can be done in high school which will not only enable those who go to college

to better avail themselves of the increased opportunities to learn more chemistry, and there is certainly plenty of it to learn, but would also be of great benefit to the many who will not go to college.

It is also a good plan for chemistry teachers to cultivate the friendship of the representatives of those firms that deal in chemical supplies and in the products of chemical industry. They are all intensely interested in things chemical both from the standpoint of general interest and of commercial possibilities. There is not one of them but would go out of his way to talk up the American Chemical Society and everything it stands for, particularly chemical education. They know very well that the greater the interest taken by instructors, the greater will be the requirements for materials and, following down the line, the greater will be the number of suggestions to the superintendents which will consequently redound to the interest of the dealers. A member of this committee knows four men, all college graduates and at one time teachers of chemistry, who represent various companies both in the west and middle west, who are quite enthusiastic about this sort of missionary work. One has already started and is distributing to each chemistry teacher whom he interviews in the high schools a few of the printed forms sent out from the committee of 1926 as what constituted perhaps the best courses in high schools.

LOUIS W. MATTERN, *Chairman*
JOHN T. FULTON
HAL WALTERS MOSELEY
M. CANNON SNEED
CHARLES H. STONE

Seeking New Uses for Sugar through Research. Stimulation of the American sugar industry on new lines is contemplated by Rudolph Spreckels of the Federal Sugar Refining Company, New York, who plans to establish a research laboratory not only to develop improved methods of refining but to find other uses for sugar than as a food product, as he writes to the *Manufacturers Record*. "The sugar industry has been carried on a very unsatisfactory basis for years, owing to overproduction of raw sugar and an over-capacity in refining," he says, and he hopes by developing new uses for sugar to remedy this situation.

As in the case of many other industrial leaders in various lines, experience has convinced Mr. Spreckels that "the backbone of success" in the development of new uses rests very largely on scientific research. Resort to research and chemical experimentation proved so successful long ago that fine laboratories now are a regular part of the equipment of hundreds of plants of the greatest industrial concerns. And the results of such research and chemical investigation have proved so remunerative that the benefits have been extended to the country as a whole, rather than restricted to individual industries.

There is no doubt that such laboratory work as Mr. Spreckels plans will do much for the sugar industry, and consequently for the South and the entire country.—*Man. Rec.*, 58, Mar. 14, 1929.

Chemical Digest

ABSTRACTS

TEACHING METHODS, AIDS, APPARATUS, AND SUGGESTIONS

Lecture Experiments on the Synthesis of Ammonia by Means of Calcium Cyanamide. H. ZEITLER. *Z. physik. chem. Unterricht,* **42,** 16–21 (Jan.-Feb., 1929).—Detailed directions and five diagrams are given. The various experiments are also suitable for laboratory work. Calcium carbide is first made by the action of carbon on calcium oxide in a graphite crucible. The two poles are a large carbon electrode and the ring which supports the crucible (Figure 1). The calcium carbide is then mixed with 10% by weight of calcium chloride as a catalyst and the mixture is placed in a small combustion tube. Dried nitrogen is passed over this heated mixture and calcium cyanamide is formed.

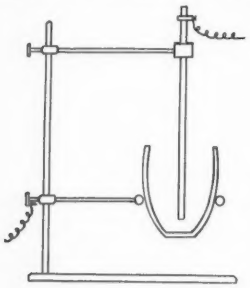


FIGURE 1

To prove the formation of this compound the latter is treated with water and the gas evolved is tested with an indicator. Two difficulties arise: (1) the raw materials themselves are liable to give off basic gases; (2) calcium hydroxide may spatter during the violent reaction between calcium cyanamide and water and thus spoil the test. These difficulties may be overcome in this way. By running check experiments on the original calcium carbide and the cyanamide found, it can be shown that the latter affects the indicator much more rapidly than the former. By the use of a clever little set-up the calcium hydroxide is prevented from getting in contact with the indicator. This set-up consists of a 1-liter Florence flask, a piece of cork, and a test tube. The test tube which has a perforated bottom is suspended in the flask by means of the cork (Figure 2). Wet pieces of phenolphthalein paper are pressed to the inside wall of the test tube, not lower than 3 cm. from the bottom of the tube. At first the stopper with the test tube is removed. The calcium cyanamide or calcium carbide is placed in the flask and water is added. After the first violent reaction has somewhat subsided the stoppers are replaced in both flasks and a comparison is made of the velocities at which the two strips of paper are turned red. Phenolphthalein is used rather than litmus because the difference in the shades of white and red can be seen more easily from far away than the difference between red and blue. Experiments are also described for the further oxidation of ammonia by means of oxygen or ozone.

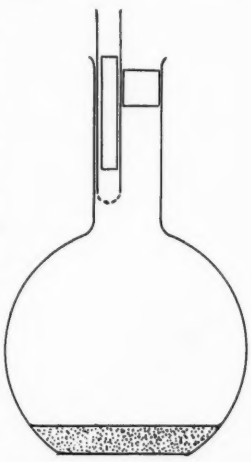


FIGURE 2

L. S.

An Experiment Illustrating the Hydrolysis of Sodium Chloride. HORST BRÜCKNER. *Z. physik. chem. Unterricht,* **41,** 92–3 (Mar.-Apr., 1928).—The hydrolysis of a salt of a strong base and a strong acid which has practically been neglected so far can be illustrated by the following simple experiment. A small quantity of sodium chloride is melted in a platinum crucible at a temperature of 1100–1200°. 1 cc. of water is added to the melt. After about 20 seconds $^1/_2$ cc. has evaporated. The drop dancing under the effect of the heat is then allowed to fall into a very dilute solution of blue litmus which will change color. The small quantity of melted salt sticks to the crucible. After cooling, the salt is dissolved in water and the solution will turn red litmus blue.

The time necessary for this experiment is one minute. The author does not state that the identical experiment has been described previously by Stieglitz in "Qualitative Chemical Analysis," Vol. I, The Century Company, **1923,** p. 179. L. S.

A Siphon Which Starts by Itself. W. GROHMANN. *Z. physik. chem. Unterricht,* **41,** 94–5 (Mar.-Apr., 1928).—A piece of glass tubing having an inside diameter of about 8 mm. is heated and drawn out to a capillary of about 1–1.5 mm. It is then bent to a *V*-shape. The two arms must be of unequal lengths. If such a siphon is placed into a vessel which is nearly completely filled with a liquid, then the siphon will start working by itself due to capillary forces. L. S.

An Aspirator. O. RODE. *Chem.-Ztg.,* **52,** 601 (Aug. 1, 1928); **52,** 721 (Sept. 12, 1928).—The aspirator (Figure 1) described uses only ordinary bottles of 5–6 liter (or 2–3 liter) capacity thus obviating the necessity of having bottles with an opening at the bottom. They are closed with 2-hole rubber stoppers; a glass tube bent at right angles passes through one hole and extends to the bottom of the bottle, while a 3-way stopcock passes through the other and extends only to the bottom of the stopper to avoid the formation of a dead space. The two flasks are connected with a rubber hose and if one is placed lower than the other, water will, of course, flow. When in use, the water is covered with a thin layer of machine oil to prevent absorption of gas. The 3-way stopcock serves to allow the sweeping out of the space above the water with the gas to be measured, and a pinch-clamp on the rubber tube adjusts the flow. Hourly regulation cannot be avoided since the initial flow of gas must be altered as the relative positions of the water level in the two bottles changes. The contrivance shown in Figure 2 permits this to be very easily accomplished. The hose is broken in the middle and a small glass tube attached to each end; these tubes are injected into rubber stoppers held together with a larger glass tube. The rate of flow within this space may be easily seen and therefore very easily adjusted. C. E. M.

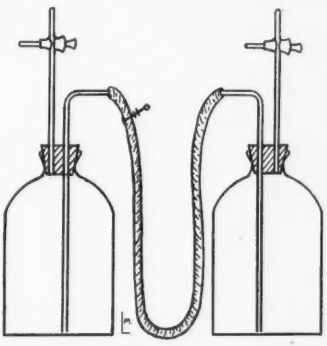


FIGURE 1

FIGURE 2

Conserving Hydrogen Sulfide Gas in the General Chemistry Laboratory. G. N. QUAM. *Chem. Analyst,* **18,** 14–5 (Mar. 1, 1929).—The device described is not new in principle (literature references are given). Briefly, the scheme is to restrict the outflow of gas at individual vents and at the same time indicate to the student by means of a washbottle that the gas is flowing.

"*Apparatus* (*Set-Up*). The gas from the large hydrogen sulfide generator *G*, Figure 1, was distributed through a line of 8 mm. glass tubing to eight outlets *O* conveniently located at the ends of the tables near windows. Thus students at one side of a labora-

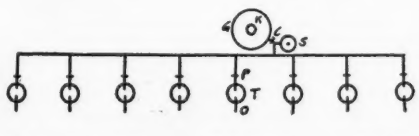


FIGURE 1.—DIAGRAM, H_2S GENERATOR SET-UP

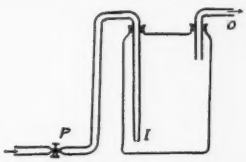


FIGURE 2.—H_2S GAS OUTLET

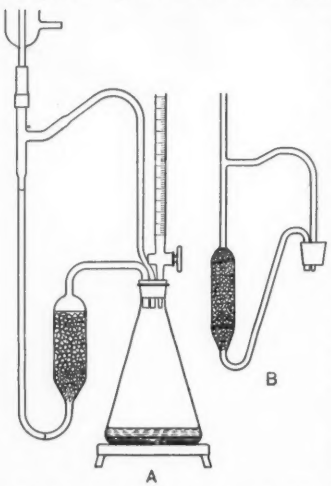
tory table had access to a separate hydrogen sulfide gas supply vent under good illumination for observation of precipitation. The generator was placed at the end of a table near a drain making it convenient to discharge the spent acid through a siphon directly into the sewer, thus avoiding the trouble of moving and taking it down except when charging with iron sulfide. Each outlet vent *T* of Figure 1 consisted of a two-necked Woulff bottle, Figure 2 (a bottle equipped with a two-hole stopper would serve as well)

equipped with outlet tube *O* and inlet tube *I* which dipped into the wash water and thereby indicated with bubbles the flow of gas. Tube *I* was constricted at the lower end until the opening was about 1 mm. in diameter. The discharge of gas when pinch clamp *P*, held to the tabletop with a staple, was released was strong enough for effective reaction but not so excessive as to cause flooding of the acid in the generator or the unnecessary pollution of the atmosphere. Safety tube *S* of Figure 1 was a suction flask, equipped with a one-hole stopper and a long open glass tube, connected to the gas line by means of the side tube, thereby compensating any change in pressure in the line when all pinch clamps *P* and stopcock *C* were closed. The safety tube obviated the flooding of the line with water from the wash bottle and clogging of the tube *I*.

"Leakage of hydrogen sulfide gas into the room from the top of the generator was avoided by a potassium hydroxide wash bottle.

"*Advantages.* The author found that charging the Kipp generator once with iron sulfide was more than sufficient for a group of ninety students throughout a twelve-week course in qualitative. The amount of hydrogen sulfide gas in the atmosphere was seldom noticeable in a laboratory unequipped with a special ventilation system. The students became familiar with the complete process of producing their supply of hydrogen sulfide without the inconvenience of the individual generator with its poor control of supply." M. W. G.

Continuous Laboratory Extractor for Liquids. A. W. FRANCIS. *Ind. Eng. Chem. (Analytical Ed.)*, **1**, 15 (Jan. 15, 1929).—"Continuous extractors for liquids with volatile immiscible solvents have been described in the literature [Fiske, *Am. Chem. J.*, **41**, 510 (1909); Berlin, German Patent 251,459 (June 24, 1911); see *C. A.*, **7**, 7 (1913); Watkins, *Ind. Eng. Chem.*, **17**, 612 (1925); THIS JOURNAL, **5**, 1351 (Oct., 1928); **6**, 160–1 (Jan., 1929); **6**, 796 (Apr., 1929)], but most of them require either elaborate glass blowing, or else, since fairly large volumes of solution are used, the extraction is very slow.



"A simple apparatus was devised for the analytical extraction of liquids. Two forms are illustrated (*A*) for solvents lighter than the extracted solution, and (*B*) for heavy solvents. Each is made from a pipet of any desired size with the stems bent and connections sealed, as shown. In (*A*) the bulb of the pipet is filled four-fifths full with glass beads before bending the upper stem. The bulb in (*B*) can be filled completely afterwards.

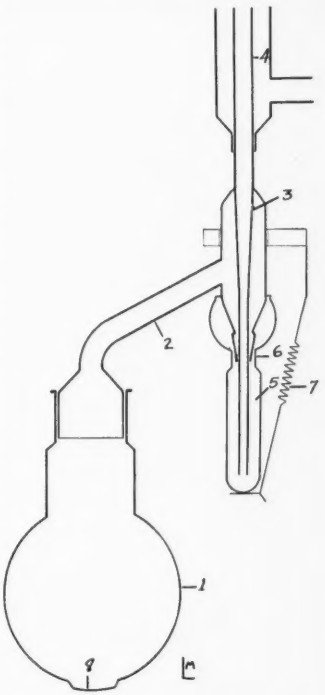
"The sample, about half the capacity of the bulb, is pipetted into the bulb, before the solvent in (*A*) and after it in (*B*). Enough solvent is used to fill the rest of the bulb and tubes and have 20 to 30 cc. in the receiving flask. The solvent is distilled by means of a hot plate through the upper tube which is bent downward to avoid excessive reflux condensation. After dropping back from the condenser, the solvent bubbles through the sample in the bulb, up in (*A*) or down in (*B*), and overflows back into the receiver.

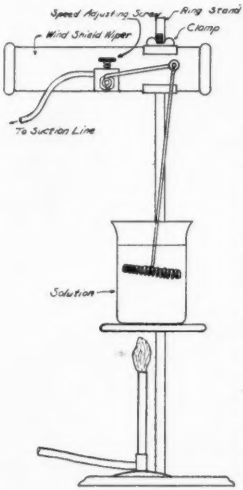
"If the extract can be titrated directly, as in the case of acetic acid, it is convenient to provide a buret and follow the extraction as it proceeds. This permits extrapolation to infinite time with great accuracy. An extraction of acetic acid from 50 cc. of salt solution with ether removed half the total in 8 minutes, half the remainder in the next 8 minutes, etc., so that in an hour the extraction was practically complete." M. W. G.

Apparatus for Determining Water by Distillation with Hydrocarbons. W. BOLLER. *Chem.-Ztg.*, **52**, 721 (Sept. 12, 1928); **53**, 70 (Jan. 23, 1929).—The apparatus shown is one in which the water content of a sample of material may be determined by distillation with an organic liquid which is immiscible with water but boils near 100°. The sample, together with about 50 cc. of benzene (used because of its low boiling point), is placed in the distilling flask *1;* the vapors escape through *2*, pass through the opening *3*, and are condensed in the tube *4* which is surrounded with cooling water. The condensed liquid then drops down through a capillary tube into a graduated flask *5*, where it forms

two layers. The graduations on this flask indicate volumes up to 1 cc. In a tube 5 mm. in diameter the divisions may be made 1 mm. apart and will indicate a volume of 0.02 cc. The entire graduate holds from 1.2 to 1.5 cc. It is ground onto the upper part at *6*, being kept from falling by the spring *7*, and is removed from the apparatus before reading the volume.

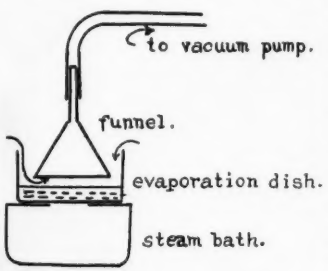
In order to avoid disagreeable bumping in the case of fibrous or powdery substances, the sample may be placed in a small bag of fine silk bolting cloth which is kept from adhering too closely to the flask by the protuberance shown at *8*. C. E. M.





Stirrer from Windshield Wiper. A. V. MOTSINGER. *Ind. Eng. Chem.*, **21**, 192 (Feb., 1929).—"The writer, recently in need of a stirrer for use in a melting-point determination, found that the mechanical suction part of an automobile windshield wiper with the stirring rod attached to it made an ideal stirrer as the speed and stroke could be easily adjusted. A short arm was made from a piece of wire and the stirring wire and wiper attached to it as shown in the accompanying illustration. This stirrer is inexpensive and can be used in any laboratory where there is a suction line." M. W. G.

An Apparatus to Prevent the "Creeping" of Solvents in Evaporation Vessels. A. B. KNOEBEL. *Chem. Analyst*, **18**, 17 (Mar. 1, 1929).—"Extraction solvents such as alcohol and benzol when caused to evaporate and separate from their solutes have the tendency to 'creep' over the entire inner wall of the retaining vessel before volatilizing. The result is that the solute or extract to be weighed is distributed over the entire inner wall of the vessel at points where a loss might be incurred. In some cases some of the residue is left on the rim of the vessel where it might be brushed off or blown away. Deposition of the residue at such inconvenient points can be avoided by removing the vapors before they can condense on the wall of the dish. A funnel is inverted into the dish just above the liquid. Air is drawn through the inverted funnel until evaporation is complete.

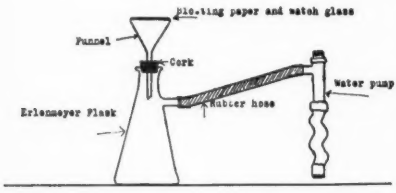


"In addition to having the residue distributed in the bottom of the dish, two other advantages are had through the use of the apparatus:

"1. The evaporation time is greatly reduced.

"2. No loss by spattering or boiling can occur. The rapid removal of the vapors keeps the liquid well below its boiling point." M. W. G.

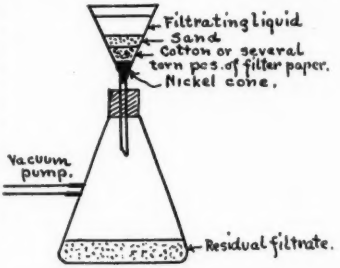
A Simple Oil Filter Apparatus for Rapid Filtration. R. E. GOODE. *Chem. Analyst*, **18,** 16 (Mar. 1, 1929).—"The apparatus consists of a suitable size Erlenmeyer extraction flask, a glass funnel with cork attachment to fit the opening in the Erlenmeyer flask head, a piece of blotting paper the size of the funnel covering the edges, and over this a watch glass of the same size. A vacuum is created in the Erlenmeyer flask by means of a water filtration pump connected to the suction of the pump, and thence to the outlet on the Erlenmeyer flask. Wetting the blotting paper thoroughly before covering the funnel serves to make the apparatus airtight."



This apparatus may be applied on numerous occasions for the filtration of substances in analytical work. M. W. G.

Method for Filtering Colloidal Substances. Y. A. FISSIAULT. *Chem. Analyst*, **18,** 17 (Mar. 1, 1929).—"On a suitable Erlenmeyer a funnel is set up in the bottom of which a nickel cone was adapted along with a piece of cotton (absorbent), then about an inch deep of sand is thrown on. The coarseness of the sand and the cleanliness of the filtrate follow the same curve. Cotton can be replaced at will by filter paper which was put aside on account of its bottom giving away under the pressure caused by air rarefaction in the Erlenmeyer."

This method of filtering gives very satisfactory results with such difficultly filterable precipitates as barium sulfate and silver chloride. M. W. G.



P—Vacuum pump
L—Filtrating liquid
S—Sand
O—Cotton or several little torn pieces of filter paper
C—Nickel cone
R—Residual filtrate

KEEPING UP WITH CHEMISTRY

The Gamma Rays of the Element Potassium. A. SALMONY. *Chem.-Ztg.*, **53,** 137 (Feb. 16, 1929).—Dr. Kohlorster from Berlin was the first one to announce that the element potassium was capable of emitting gamma rays. Except for radium and its decomposition products this is the only element which has this power. The amount of potassium occurring in a certain locality can be estimated from the occurrence of gamma rays and the electrical conductivity of the air in that locality. From such studies it has been found that 1.52% of the earth's crust was potassium.

By subjecting a heart that has been removed from an animal body to the influence of radium, Dr. Zwaardemaker succeeded in causing it to beat again. This proved that a radioactive substance was present in the heart. Potassium has finally been found to be the source of the radioactivity. The element acts indirectly on the heart by first activating a substance called "automatin" which is present in the heart. This substance gradually disappears from the isolated heart, thus stopping the heart beat. Some of the physical and chemical properties of automatin are known, as, *e. g.*, its solubility in alcohol and its insolubility in benzol and ether. Automatin has been isolated and was found to be active only when it was subjected to the rays of potassium or other radioactive substances. L. S.

Chemical Development and Fixation of Invisible Finger Prints. G. POPP. *Z. angew. Chem.*, **41,** 1005–7 (Sept. 8, 1928).—If a finger print is not visible it can be made so by mechanical or chemical treatment. The mechanical method consists of brushing the surface of the object with a fine powder like aluminum, carbon black, indigo, cinnabar, etc. The chemical methods are described in detail in Robert Heindl's book on "System und Praxis der Daktyloskopie," Leipzig, **1922,** p. 303. They are based on the fact that the substances deposited from the fingers on the object will react dif-

ferently from the object when the latter is treated with a reagent. Perspiration contains 98.5–99.5% of water and 0.5–1.5% of solid material. One-third of the latter is sodium chloride while the remainder consists of organic substances like urea, volatile fatty acids, protein, skin cells, fat, etc. The following substances are also recommended: mercurous nitrate, silver nitrate, eosin, fuchsin, tannin, diluted ink, and others. All of these methods do not work well in practice, partly because the finger marks are not made sufficiently visible and partly because the images are too perishable. Best results seem to have been obtained by the treatment with cold vapors of iodine. In this way the finger prints can be made visible very quickly. The disadvantage is that the iodine picture disappears rather quickly. This can be overcome by (1) photographing the pictures as soon as they are formed, (2) enclosing the iodine prints within sealed glass plates, (3) fixation as iodine-starch, mercuric iodide, thallium iodide, silver iodide, potassium-iodoplatinate, or palladium iodide. Fixation with a very dilute solution of palladium chloride (1:1000) works best. If an iodine finger print is treated with such a dilute solution it will gradually turn deep brown; after washing and drying it will be permanently stable. L. S.

Acids and Bases. N. F. HALL. *Rep. N. E. A. C. T.*, **30,** 91–6 (Mar., 1929).—It has come to be recognized that when a small amount of a strong acid is dissolved in water, a definite chemical reaction occurs, and one which is substantially complete. For example:

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$
$$H_2SO_4 + H_2O \longrightarrow H_3O^+ + HSO_4^-$$

Strong acids, when dissolved in water, really all change into the weaker acid H_3O^+ or $H^+(H_2O)$. It is for this reason that the properties of all strong acids in moderately dilute solutions are so similar; they are all solutions of the same acid. The extent of the *dissociation* of the acid will depend on whether the solvent or the acid anion is more avid of protons or, as Brönsted expresses it, according to which is the stronger base; for Brönsted proposes to define both acids and bases by a single equation: $A \leftrightarrows B + H^+$. Thus an acid is any substance which liberates protons and a base any substance that picks them up, irrespective of the charge of the acid or base. O. C.

The Production and Uses of Tantalum. G. M. DYSON. *Chem. Age* (*Met. Section*), **20,** 18–9 (Mar. 2, 1929).—This article outlines the history of the discovery of the metal, its occurrence, methods of extraction and uses. Its use in filaments in electric light bulbs has given place to tungsten. It has some use as an acid resisting (except HF) substitute for platinum especially for low-temperature work. It is attacked by fused alkalis. It has possibilities in radio valves owing to its great ability to absorb gases at high temperatures. E. R. W.

Basic Industrial Minerals: No. 5, Gypsum. G. M. DYSON. *Chem. Age*, **20,** 252–3 (Mar. 16, 1929).—The different forms of gypsum, methods of calculation, and uses of this mineral are briefly presented. Besides its familiar uses in the arts and industries there is mentioned its use in agriculture. It helps in maintaining soil fertility by accelerating the decomposition of zeolites and double silicates of magnesium and potassium. It also helps to retain soil moisture. E. R. W.

Chemistry and Leather. J. A. WILSON. *Ind. Eng. Chem.*, **21,** 180–90 (Feb., 1929).—The Chandler lecture for 1928. A comprehensive survey of the chemistry of leather. M. W. G.

The Many-Sidedness of Glass. E. C. SULLIVAN. *Ind. Eng. Chem.*, **21,** 177–80 (Feb., 1929).—The Perkin lecture for 1929. A brief survey of the chemistry and physics of glass, with an indication of numerous problems which might be profitably investigated by the scientist. M. W. G.

Vitamins and the World of Plants. N. A. CLARK. *Sci. Mo.*, **28,** 343–8 (April, 1929).—Vitamins are formed outside the animal world. They are found in plants and in certain microörganisms. The theory has been put forward that it is bacteria alone which are capable of synthesizing the vitamins; that they carry them to the green plants, and that the vitamin content of the plant is as incidental as that of the animal. While this theory has not received general support, it is known that certain marine algae contain large quantities of vitamin *A*, and that this is concentrated in the fish that eat them. These diatoms can synthesize the vitamin from inorganic sources under the influence of sunlight. Fresh water algae act in the same way. Many species of bacteria as well as yeasts can manufacture vitamin *B*. Green plants produce all the known vitamins, but in different plants and in varying quantities. The problem is complicated by the existence of stimulating substances in organic matter which may affect the quantity of the essential vitamins formed. G. W. S.

Why We Need Minerals in the Diet. A. LAUTZ. *Pract. Home Econ.*, **7**, 85 (Mar., 1929).—While there are some 13 minerals in the human body, calcium, phosphorus, iron, and iodine are the ones which we are apt to miss in their proper amounts. Calcium and phosphorus are responsible for the rigidity and firmness of teeth and bones. Calcium helps control muscle contraction, heart beat, nervous reactions, and blood coagulation. It regulates wrong amounts of Na, K, and Mg in the body. Phosphorus is found in the body in more compounds than any other mineral. It is prominent in every cell making up part of the lecithin, glandular, and nervous tissue, sexual elements, milk and bones. It helps keep the blood neutral and in regulating the burning of carbohydrates. Iron is part of the chromatin which is essential for the life of every cell. Being also part of the hemoglobin of the blood it thus functions indirectly in many vital processes. Iodine is found in the thyroid gland, the secretion of which influences the rate at which our cells burn, the state of our nerves, our emotions, and even the working of our minds. Insufficient iodine in the diet during growth retards normal development. Goiter is one of the visible disagreeable signs of insufficient iodine intake. Sulfur as part of protein regulates cell burning. Sodium chloride influences the amount of water taken in and hence the firmness of flesh. Chlorine as hydrochloric acid is necessary for gastric digestion. The functions of the traces of fluorine, silicon, and manganese in the body remain to be investigated. J. W. H.

What Is Light? A. H. COMPTON. *Sci. Mo.*, **28**, 289–303 (April, 1929).—An address in which it is shown that certain light effects can be explained only on the basis that light consists of waves, while other effects necessitate the existence of light as particles. C. reviews the various electromagnetic radiations pointing out their similarity in that they are wave-like in character but with different wave lengths. Photoelectric effects, however, are explained best on the basis that light consists of particles. These particles are now commonly called "photons." With this view the energy of motion obtained when an electron strikes the target of an x-ray tube is transformed into a photon. It is not usually possible to describe the motion of either a beam of light or a beam of electrons without introducing both the concepts of particles and waves. Because of the fact that the wave-mechanics theory does not permit the location of a photon or of an electron except at the instant at which it does something, it is impossible to assign a position to a particle in between its actions on other particles. It is only to satisfy our sense of continuity that we assume that an electron or a photon has a real existence between the occasions at which it acts on other particles. It would be equally permissible to suppose that light or cathode rays alternate in form between particles and waves. While experiment on interference and diffraction shows that light consists of waves, the photoelectric effect and the scattering of x-rays give equally convincing reasons for believing that light consists of particles. C. concludes that light is propagated as electro-magnetic waves, but whenever it does something, it does it as photons. G. W. S.

Chemical Possibilities in the Control of the Chinese Situation. F. CLOSE. *Chem. Warfare*, **15**, 532–5 (Mar. 15, 1929).—A presentation of the use of chemicals as a more humane method of exercising military force in the Orient. The use of rifles, machine guns, and ships guns, in the protection of the citizens of neutral nations, is accompanied by undesirable loss of life. The same protection, without loss of life, might be accomplished through the judicious use of tear gas, white phosphorus, or cyanide grenades. These agents should be especially effective against poorly organized, superstitious masses. E. R. W.

HISTORICAL AND BIOGRAPHICAL

Russell Henry Chittenden. G. LUSK. *Ind. Eng. Chem.*, **21**, 91–2 (Jan., 1929).—An appreciation. M. W. G.

David Wesson. J. C. OLSEN. *Ind. Eng. Chem.*, **21**, 290–1 (Feb., 1929).—A life sketch. M. W. G.

Winthrop Carver Durfee. L. O. OLNEY. *Ind. Eng. Chem.*, **21**, 390 (April, 1929).—Biographical. M. W. G.

Homer J. Wheeler. E. W. ALLEN. *Ind. Eng. Chem.*, **21**, 510–1 (May, 1929).—Account of Dr. Wheeler's contributions to agricultural research in America. M. W. G.

The Total Number of German Chemists. F. SCHARF. *Z. angew. Chem.*, **41**, 1164–6 (Oct. 20, 1928).—The total number of German chemists is estimated by the *Verein deutscher Chemiker* as 12,500. They are distributed in this way: in the chemical industry, 5500; in other industries, 4500; in public laboratories, 500; in teaching and other official positions, 1500; in foreign countries, 500. L. S.

Perkins Medal Award. *Ind. Eng. Chem.*, **21,** 177 (Feb., 1929).—A short account of history of medal with list of recipients. The address of the 1929 recipient, Eugene C. Sullivan, on "The Many-Sidedness of Glass" is published directly following (see THIS JOURNAL, page 1165). M. W. G.

Chandler Lecture. *Ind. Eng. Chem.*, **21,** 180 (Feb., 1929).—A short account of history of medal with a list of recipients. The address of the 1928 recipient, John Arthur Wilson, on "Chemistry and Leather" is published directly following (see THIS JOURNAL, page 1165). M. W. G.

EDUCATIONAL MEASUREMENTS AND DATA

The Pearson Formula and a Further Note on the Kuhlman-Anderson Tests. F. KUHLMAN. *J. Appl. Psychol.*, **13,** 32–45 (Feb., 1929).—The writer contends that a high correlation may be due to the same factors causing similar errors in both series of measures between which the correlation is computed and that the workings of the Pearson formula reveal a number of ways in which it fails to permit each case to contribute to the coefficient of correlation in proportion to the agreement between the two measures on it. Cases for illustration are given. A substitute for the Pearson formula is illustrated. The Kuhlman-Anderson tests are discussed in relation to the procedure involved.

The writer concludes: (1) that no test can give uniformly good results at different age levels and (2) a battery of tests will show a high degree of validity and reliability as determined by the visual Pearson correlation formula. The poorer the tests in the traits under consideration the higher will be the Pearson r between the test's results and another criterion, and between the two halves of a battery of such tests. Statistical data, tables, and graphs are included. S. R. P.

Correlation between Intelligence Quotient and Accomplishment Ratio. H. R. DOUGLASS AND C. L. HUFFAKER. *J. Appl. Psychol.*, **13,** 76–80 (Feb., 1929).—A discussion of the negative correlation as obtained between intelligence quotients and accomplishment ratio. The authors hold that this phenomenon is not due to errors of measurement but to the unique nature of the correlation coefficient between a variable and a ratio of which the first variable is the denominator. Bibliography and statistical data are included. S. R. P.

A Mental Alertness Examination for the Working Age Level. R. S. SCHULTZ. *J. Appl. Psychol.*, **13,** 46–61 (Feb., 1929).—A description of an intelligence test devised by Dr. Morris S. Viteles of the University of Pennsylvania, for use in vocational guidance for the employment bureau. Features of the test are: the interesting nature of the items, the self-administering phase, and the twenty-minute time limit. Validity and reliability are determined as well as group differences such as race, grade, sex, and age differences. Tables, graphs, and statistical computation are presented. S. R. P.

THE METHODS AND PHILOSOPHY OF EDUCATION

The Development of Educational Method. J. P. WYNNE. *Educ. Admin. & Superv.*, **15,** 161–74 (Mar., 1929).—An analysis of the procedure in the development of educational method. The points discussed are: (1) the development of method through logical analysis, (2) the employment of principles as technics, (3) the problems in the present situation of the field of method, (4) the development of a principle of experience into communicable principles of procedure.

The problems in method at the present time are clearness, integration, and communicability. These may best be overcome by (1) the selection of the most comprehensive conception of experience, (2) the selection of the practical conceptions of the learning-teaching relationship, (3) the formulation of the implications of the conception of experience into principles with reference to each of the practical conceptions. The conception of experience as a process of dynamic adjustment seems to be the most valid attitude toward life.

Bibliography is included. S. R. P.

Consolidating General and Special Methods. E. G. WALKER. *Ohio Teacher*, **49,** 309 (Mar., 1929).—There is great duplication in educational courses, and this duplication is probably greatest between the general and special methods courses. Why not consolidate these two or do away with the general methods course? The special methods courses can be sufficiently generalized and in educational psychology the student will find further generalization if needed. Orientation courses such as "Introduction to Teaching" should be discarded. S. R. P.

Creative Work in Education. I. Increasing Our Inheritance. R. JONES. *Educ.*

Outlook, **81,** 9 (Jan., 1929).—Two views regarding creative work in education are presented. *The 19th century view:* "the school will hand on knowledge and give practice. As for creative work, it is rare and mysterious. It arises of itself and is beyond control or direction or encouragement." *The 20th century view:* "the power to produce beauty is not a gift grudgingly given by the gods to a mere sprinkling of fortunate beings, but an ability which, though varying in strength like other abilities from individual to individual, is yet as universal as the power to learn arithmetic." M. W. G.

Creative Work in Education. II. What Is It? R. JONES. *Educ. Outlook*, **81,** 51 (Feb., 1929).—There is a tendency to suppress creative work in the schools—a tendency to pass on only that of which society approves and this circumscribes teacher and pupil. But even in the closest imitation there is an individual difference and this difference is the genesis of creative work. The author says that from the nature of their work teachers tend to become standard, to "stay put." S. R. P.

Creative Work in Education. III. On Keeping Up Early Stimulus. R. JONES. *Educ. Outlook*, **81,** 81–2 (Mar., 1929).—A plea for the continuance through the high school and university of the stimulus to creative work which is at its highest in our present schools, in the primary school, and lowest in the university. S. R. P.

The Doctor of Philosophy and His Business. J. P. GOODE. *Science*, **69,** 318 (Mar. 22, 1929).—*I. The Business of Making a Doctor.* This is one of our flourishing industries. About one hundred and fifty thousand graduate students are seeking advanced degrees. The industry is young. Yale University conferred its first Ph.D. degree in 1861. The problem of turning raw material into Ph.D.'s is a difficult one because of the variable nature of the raw material. Individual instruction and personal contact mean most to the graduate student. The personal conferences with the instructor bring out all the faults of the student such as "mental obliquities, faulty preparation, lack of logic, and deficiencies in language." The fundamental virtue is intellectual integrity.

Most advanced students are under the necessity of earning their own living and providing for their education. These necessities, while handicaps, do not compare as such with "easy money" and "wealth assured." Fellowships, while good, are not an unmixed blessing, as they may cause an impecunious student to shop around for the most attractive fellowship—he then is not choosing courses, or even men, but bargains. Fellowships which provide free tuition and the privilege of borrowing from a loan fund are in successful operation in several universities. They accommodate a maximum of students, do not pauperize, and the fund is perpetual. *II. The Doctor's Business.* Many industries employ doctors of philosophy for research work. There is also a great opportunity for research in preventive medicine, etc., but more than half of our doctors of philosophy become teachers. The function of the doctor, be he researcher or teacher, is to make his work available and intelligible to intelligent people not specialists in his field. G. H. W.

The Rollins College Conference Plan. H. HOLT. *School*, **40,** 469–70 (Mar. 14, (1929).—Rollins College limits its enrolment so that each teacher is restricted to ten or twenty students. The day's schedule is blocked into two-hour periods. During each period the class and teacher work together using the first hour for study and preparation and the second hour for reports and discussion. As students advance and show differing abilities the work is differentiated to meet these needs. Some courses have the year's work assigned at the first of the semester enabling the student to make progress as fast as he may, completing the course and applying his released time to other courses in which he may not be progressing so successfully. The ideal of the plan is to make the professor a "guide, philosopher, and friend" to the student instead of "a lecturer and quizzer." B. C. H.

All-Year School. F. W. BAIRD. *Ohio Teacher*, **49,** 315–6 (Mch., 1929).—The summer vacation for children is a waste of opportunity, time, and money. Perhaps great evil results from the unrestrained and unguided freedom during the summer vacation period. Why not benefit from this period? In the all-year school the child starting at six would graduate from high school at the age of fifteen. For the following four years if the child works he will be able to pay for half of his own progress through the grades and high school. All-year schools exist in some form in almost all the large cities. S. R. P.

The Superintendent of Schools and Research. A. J. JONES. *Teachers J. & Abstr.*, **4,** 133–4 (Mar., 1929).—Abstract of an article from *Educ. Admin. & Superv.*, February, 1929. The writer discusses the relation of research and the research attitude of mind to the school superintendent. The steps in research procedure are outlined as follows: (1) selection, limitation, and formulation of the problem to be solved; (2) selection and

organization of the data with reference to the problem; (3) critical analysis of the data; (4) the formulation of the hypothesis; (5) a final testing of the hypothesis; (6) applications of the conclusions. Every superintendent should not only have the research attitude of mind but should carry on some piece of research. A short bibliography on research technic is included. S. R. P.

A Way Out for the Junior High Schools. P. W. L. COX. *School*, **40**, 521–2 (Apr. 4, 1929).—The modern forward-looking junior high school is having to face a barrage of criticism. This criticism points toward curriculum and quality of graduating student. For a junior high school, education is defined as "growth in the integration of personality, growth in aspiration and creative urge." If education is this, then "the public's school should be used for all of the public's children." Ability grouping upon entrance to senior high school is suggested as one effective way of making college admission more certain for those qualified for it after graduation. B. C. H.

The Question of Home-Work. J. H. WADE. *School*, **40**, 527 (Apr. 4, 1029).—Cautions which those urging home-work should bear in mind are: in many homes there is no proper place for home-work, parents do not coöperate in helping to get it, children often do it after they should be in bed. A list of nineteen suggestions upon the character, amount, and administration of home-work is given. B. C. H.

Experimental Mines Prove Practical Aids in Colleges and Industries. C. H. VIVIAN. *Compressed Air Mag.*, **34**, 2725–9 (Apr., 1929).—An account of what various American colleges, offering courses in mining, have done to round out the theoretical instruction with practical training. Although it is not the purpose of these institutions to turn out "practical" workers, every effort is being made to give the students a fair knowledge of industrial methods and practices. These methods vary from experimental mines owned by the college to arrangements with privately owned mines for summer work by the students. E. R. W.

Education in Norway and Sweden. H. J. FALLS. *Educ. Outlook*, **81**, 54 (Feb., 1929).—At present Norway offers a seven-year elementary course, a four-year middle course, and a three-year gymnasium course. There is one university at Christiania. In Sweden the church and education are both under the same department. There are six years elementary, four years secondary, and three years gymnasium. There are four universities. Stockholm is now the most crowded of the Swedish universities. S. R. P.

Education in Japan. C. BOYD-BOWMAN. *Educ. Outlook*, **81**, 90 (Mar., 1929).—A description of educational conditions in Japan. Illiteracy has been reduced to 1 per cent of those called for military service; the primary schools give a six-year course starting at the age of six years; the secondary schools extend over a period of five years; higher schools, preparatory for college give a three-year course; there are five Imperial universities and nearly forty colleges of university rank; higher education for women has hardly yet begun but is gathering momentum; there is complete separation of religion and education. S. R. P.

THE PHILOSOPHY OF SCIENCE

To Whom Does Science Belong? P. PAINLEVÉ (Quoted from *Revue de France*) *Rev. Revs.*, **79**, 133 (Mar., 1929).—Does science contribute to the good will between nations? After the experiences of the World War there is reason to doubt. While scientific knowledge has grown with ever-increasing rapidity faith in science has declined. "Science has a sovereign indifference to good and evil. . . . . The intellectual élite of each country has as its mission the improvement of the genius of that country, to manifest in their highest forms all the nuances of thought and feeling which characterize the personality of that country among others." G. H. W.

Some Next Steps in Science Teaching. O. W. CALDWELL. *Rept. N. E. A. C. T.*, **30**, 98–108 (Mar., 1929).—What we really need to know and science teachers are keen to know, is, what parts of science knowledge should be and can be distributed to the public; what parts should be given to those who hope to become scientific research men and what parts should be printed only and laid away in libraries for possible use through the future developments in science and education. O. C.

The Organization of Scientific Research in Industry. F. B. JEWETT, W. R. WHITNEY, AND L. V. REDMAN. *Science*, **69**, 309 (Mar. 22, 1929).—The three authors write, respectively, under the sub-headings: Finding and Encouragement of Competent Men, Encouraging Competent Men to Continue in Research, and Is Research a Gamble? G. H. W.

The Need of Perspective. *Chem. Bull.*, **16**, 122 (Apr., 1929).—"Specialization at too early a period is inadvisable," even though specialization may be necessary for

success in life. "Every man. . . . will lose perspective if he limits himself too closely to one type of activity. . . . "Science needs men who see the relationship of one field to another field." E. L. M.

The Supply of Chemists. *Chem. Bull.*, **16,** 123 (Apr., 1929).—The demand for chemists threatens to exceed the supply. The writer believes that the recent demand is based "on the growing recognition by the industries that chemists are more than luxuries," rather than on a scarcity of trained men as was the case during the war.

The author further points out, that in order to maintain this demand the colleges and universities should feel their responsibility and "turn out adequately trained men and weed out the weak individuals who would not make good." E. L. M.

THE TEACHING PROFESSION

The Basis of Teacher Rating. J. BAIRD & G. BATES. *Educ. Admin. & Superv.*, **15,** 175–83 (Mar., 1929).—An analysis of the ratings made by one hundred and twenty-eight principals on five hundred and seventy-one teachers in Detroit. To determine the correlation between the rating given the teachers by the principals, and school success as measured by standard tests in reading given to grades I, II, and III and to determine the relation between the general merit rating and that given in special characteristics. The findings of the study indicate extreme caution in the application of rating scales and the need for research to validate rating scales. Tables are presented. S. R. P.

Reading Interests of Teachers. C. R. ROBERTS AND R. A. DAVIS. *Teachers J. & Abstr.*, **4,** 151–2 (Mar., 1929).—Abstract of an article from *Educ. Admin. & Superv.*, February, 1929. A study made from replies to a questionnaire by 240 elementary and secondary school teachers who were students in the summer school of the University of Colorado.

The authors conclude as follows: "(1) Teachers as a group spend a great deal of their non-teaching time in reading. (2) Teachers display a high degree of judgment in choosing the character of material which they read. It is questionable whether strictly professional reading is of more benefit to teachers in service than reading of a general nature. Certainly a diversity of interests which can be derived only through varied reading is one of the very important factors in the interpretations and motivation of classroom work. (3) Teachers do a great deal of general reading. (4) Teachers read first for recreation and second as a direct aid in teaching." S. R. P.

Essentials of Teacher Training. B. HIGLANDS. *Ohio Teacher*, **49,** 313–4 (Mar., 1929).—A plea for instruction of prospective teachers in more subject matter and an increase in the training period from one to two years and later to four years. Prospective teachers should be given an adequate test of intelligence before entering upon the training course and at the completion of their course a test covering subject matter and methods.

The older system of teacher preparation and certification is contrasted with that which is considered desirable. S. R. P.

A Comparison of Teacher Training Centers with Schools Having a Population of Like Ability. A. J. WILLIAMS. *Educ. Admin. & Superv.*, **15,** 184–9 (Mar., 1929).—A study of the efficiency of the Buffalo plan of teacher training. The instruction in the training centers with that given in the schools having regular experienced teachers was compared. Tables are presented. The author concludes that the instruction given in the schools of the training centers is as efficient as that given in the other schools due, no doubt, to the close supervision given to the inexperienced teachers. S. R. P.

The College President and the Improvement of College Teaching. *Educ. Admin. & Superv.*, **15,** 212–22 (Mar., 1929).—A study of the replies received on questionnaires from ninety-nine liberal arts colleges and universities designed to determine to what extent and in what ways the value of training for teaching is recognized in practice and in what ways and to what extent these colleges are attacking the problem of improvement of instruction. Tables are presented.

Conclusions: About fourteen per cent of the liberal arts colleges require professional training for teaching on their staff; while college presidents and deans prefer professional training for their teachers, they do not consider it will take the place of knowledge in the major field or broad culture; where specific courses are stated as desirable, educational psychology and psychology applied to teaching take precedence; inexperienced teachers are not eligible for appointment in 64 per cent of the colleges and one-third of the colleges do not consider teaching experience in high school or elementary school of any value to college teachers; thirty-one per cent of the colleges have officers whose whole time is devoted to the improvement of instruction; there is little

tendency toward the specific supervision of instruction; sixty per cent of the colleges have professional literature available in their libraries; the middle west ranks highest in professional status of teachers and instructors; no college reporting from the northeast requires professional training; liberal arts colleges with undergraduate departments rank lowest and liberal arts colleges without departments of education rank first; privately controlled institutions rank higher than those under state control. S. R. P.

The Professional Status of Faculty Members in Pennsylvania Teacher Training Institutions. *Educ. Admin. & Superv.*, **15,** 202–11 (Mar., 1929).—A factual examination of some available data from the Department of Public Instruction bearing upon the professional preparation and experience of the teachers in the state normal schools during 1928–1929. Tables are presented.

An interpretation of the data reveals (1) that the general standard of education and training has already approximated that of the better liberal arts colleges, (2) the principle of equality of recognition for equivalent qualifications is established, (3) a more prolonged graduate training is desirable, (4) it is a questionable policy to employ teachers to the extent of one-third of the total number who have had no elementary teaching experience, (5) the median age of all members is forty years, (6) the median salary is approximately $900 more than that received by high-school teachers in cities of 30,000 to 100,000 population, and approximately $400 more than in cities of 100,000 and over. S. R. P.

Graduate Schools and College Teaching. W. W. CHARTERS. *Phi Delta Kappan*, **11,** 113 (Dec., 1928).—Dean Haggerty of the University of Minnesota has presented the statement that 75% of our doctors of philosophy become teachers. The issue is raised that graduate schools are institutions in which students should be taught not only to do research but to *teach* as well. The character of college faculties and the quality of college education, it would seem, depend upon the degree to which graduate schools measure up to these two demands upon them.

"The young Ph.D. knows the principles, the abstruse problems, and esoteric information of his field . . . . . To adapt what he knows to undergraduates is a different problem. In the solution of this he is amateurishly incompetent."

While a few graduate schools accepted the fact that they are teacher-training institutions much remains to be done even in those institutions which recognize their obligations. B. C. H.

Radium Capsules Reduce Fire Risk. Radium now fights fires by snuffing out dangerous sparks of static electricity in a large Russian rubber factory. So little radium is used that the method costs only a few dollars per year.

When rubber solution is flowed upon a fabric base and dries upon it, enormous charges of static electricity are produced from friction of the rubber-covered fabric against parts of the drying machinery. In time the pressure of these accumulated charges is raised so much that a breakdown through a discharge becomes inevitable. The hot, fat spark, exactly like the ignition spark in an automobile motor, presents a great fire hazard. Air in the drying room of a rubber factory is always saturated with highly explosive vapors, which ignite most readily.

The usual method of fire prevention consists of leading the charges of electricity away, before their pressure becomes too high. A fine wire-brush is used to collect the charges. Small sparks cannot be avoided in this way, however, and the fire danger is always present.

All this is changed when radium is placed near the point where electricity is generated. Radium rays ionize the air and make it a good conductor of electricity. The dangerous charges then flow harmlessly through the air to the nearest metallic part and thence to earth. No sparks can be produced, when radium is on sentry duty. The new method was tried out in the Russian State Rubber Factory "Treugolnik" at Leningrad and was found to be successful.

The cost of installation is reported to be very low, as one milligram of radium is quite sufficient to produce the desired results. Furthermore, it will not be necessary to renew the radium capsule, as it will last for a few centuries at least.—*Science Service*

Local Activities

Through these columns, the JOURNAL desires to render a two-fold service.

1. Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. Providing an exchange column for positions. That is: (1) any teacher who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed, however, the necessity for such action will be largely obviated.

The College of the City of New York. Professor Joseph A. Babor spoke before the Baskerville Chemical Society on April 17th on "Atomic Structure." On the same date, Professor Benjamin Harrow read a paper on "Hormones" before the Society for Experimental Biology and Medicine.

Professor Martin Meyer spoke on "The Relativity Theory" at the New York University Graduate School, Washington Square College, on April 12, 1929. Professor Meyer has translated Einstein's paper on the Field Theory, and a copy of the translation has been autographed by Einstein.

A regular meeting of the Science Section of the Faculty Research Club was held in Room 315, on April 4, 1929. The speakers were: Mr. Ruckes on "Mechanical Analogies in the Construction of Bone," and Professor Frederick A. Woll on "The Making of Spectacle Lenses."

Professor L. J. Curtman has contributed an article to the April issue of the JOURNAL OF CHEMICAL EDUCATION entitled, "A System of Individual Reagents for Courses in Qualitative Analysis."

Dr. H. C. Parmelee, Secretary of the American Institute of Chemical Engineers, will address the Society of Chemical Engineers at the College, on Thursday, May 23rd, at 12.30 P.M. The subject of his talk will be "Changes in Industry Due to Chemistry."

On Monday, April 22nd, the Chemistry 1A division gave a surprise party to Professor Estabrooke in honor of his birthday. After dining at "Louis'," the group went to the Majestic Theater where they enjoyed seeing "Pleasure Bound"—a current musical revue.

A new textbook, "General College Chemistry," by Professor Babor, is now in press. It is published by the Thomas Y. Crowell Company. The manual to accompany it is at present in preparation.

Professor Reston Stevenson spoke on "Analysis and Measurement with Physico-Chemical Apparatus" at the Twelfth Exposition of Chemical Industries, held in New York City, the week of May 6th.

Dr. L. C. Pan, instructor of electroplating, delivered a lecture on "Simplified Methods of Chemical Control of Plating Solutions" at the Education Session of the Bridgeport Branch of the American Electroplaters' Society, held at the Hotel Stratfield on April 27th.

Professor Harrow is the joint author of a book, "Beginning Chemistry" (American Book Co.).

Georgetown University. The Chemistry Academy of Georgetown University brought another successful year to a close at its last public meeting held April 11th. On the occasion of this meeting the Academy was honored with an exceedingly interesting and timely lecture entitled "Synthetic Preparations of Motor Fuels," delivered by DR. A. C. FIELDNER, Chief Chemist of the U. S. Bureau of Mines and Superintendent of the Pittsburgh Experiment Station.

Dr. Fieldner is particularly interested in the high- and low-pressure, high- and low-temperature catalytic production of motor fuels. In his discussion he described the eagerness of European countries in general, and especially of England, France, and Germany, in seeking methods for the production of an artificial substitute for natural petroleum which is rapidly disappearing in their respective lands. He accurately described the recently perfected Bergius Process for the transformation of ordinary coal to oil, the work of Dr. Fischer and Dr. Tropsch of Germany in synthesizing petroleum from carbon monoxide and hydrogen and the synthesis of methanol from carbon monoxide and hydrogen by General Patart and M. Audibert of France.

At the two previous public meetings of the year the Academy acted as host to the following speakers: MAJOR GENERAL FRIES, then Chief of the Chemical Warfare Service of the U. S. Army, whose topic was "Chemical Warfare," and DR. M. X. SULLIVAN, Chief of the Chemistry Division of the U. S. Hygienic Laboratory, Washington, D. C., whose subject was "The Romance of Chemistry and Health."

Through the courtesy of the U. S. Bureau of Mines, Pittsburgh Station, the following films were exhibited at the private meetings of the Academy: Oxygen, the Wonder Worker, November 5th; The Story of Sulfur, December 3rd; The Story of Petroleum, January 14th; The Story of Steel, February 11th; The Story of Copper, Milling, Smelting, and Refining, February 18th; The Story of Lead, Mining, Milling, and Smelting, March 6th; The Story of Asbestos, March 18th; The Power Within, April 25th; Carbon Monoxide, April 25th.

Medical College of Virginia. Dr. Garnett Ryland, professor of chemistry, University of Richmond, has been elected President of the Virginia Academy of Science.

W. A. Peabody, of the University of Colorado, has been elected a member of the chemistry faculty of the Medical College of Virginia.

Columbia University. On May 15th, Professor H. C. Sherman addressed the Delaware Section of the American Chemical Society on "Recent Advances in the Chemistry of Nutrition."

Professor Marston T. Bogert on April 20th attended the meeting of the Council of the American Association of University Professors in Washington, D. C. From April 22nd to 24th inclusive he was in attendance at the annual meeting of the National Academy of Sciences in Washington, as chairman of its chemistry section. On April 25th he visited the Farm Waste and Color Laboratories of the U. S. Department of Agriculture at Washington, as chairman of the advisory committee to these laboratories, and that same evening lectured before the Washington Chemical Society at the Cosmos Club on the subject of "Musks, Natural, Artificial, and Synthetic."

Professor V. K. LaMer lectured at Swarthmore College on "Electrical Properties of Solutions."

Dr. Maxwell Schubert, at present instructor in organic chemistry, has accepted a position as assistant to Dr. L. Michaelis at the Rockefeller Institute.

Professor A. W. Thomas lectured on Colloids before the Chemistry Club at Hunter College on May 8th.

Dr. Graham Cook, instructor in chem-

istry, has been appointed professor of chemistry at Albright College, Reading, Pennsylvania.

Professor J. E. Zanetti and H. A. Fales have been promoted to full professorships, Professors T. C. Taylor and L. P. Hammett to the grade of associate professor and Drs. D. J. Beaver and Mary L. Caldwell to the grade of assistant professor.

Syracuse University. The Annual Exposition and Kem Sho, April 26th and 27th, attracted over 3000 visitors to the chemistry building.

In addition to the conventional exhibits of apparatus, methods, products, etc., there were special booths devoted to alchemy, glass blowing, dry ice and liquid air, chemical warfare, student-made crystal and atomic models and various research projects. The services of over 150 student exhibitors were required.

In the auditorium moving pictures loaned by 30 industries were shown continuously.

At the teachers' meeting the following papers were discussed:

1. "General Methods as Applied to Chemistry," K. M. HUMPHREY, Teachers' College, Syracuse University.
2. "Chemistry's Place in the University of the State of New York," W. W. KNOX, State Department of Education, Albany.
3. "An Experiment in Methods of Teaching High-School Chemistry," I. W. HAZARD, Athens, Pa.
4. "Report of the Committee on the Employment of Chemistry Students," GEORGE W. FOWLER, Central High School, Syracuse.

For the first time the Kem Sho was held out-of-doors. Several spectacular effects were achieved, among them the explosion of two 800-pound cakes of ice by means of charges of thermit.

Since the Exposition is now considered to be a permanent and very valuable part of the year's program, the committee on Chemical Education of the Local Section will gladly exchange ideas and plans with any others who are interested. Address R. A. BAKER, Bowne Hall, Syracuse University, Syracuse, New York.

Dakota Wesleyan University. The fifth annual science open house was held on the afternoon and evening of April 26th. Extensive exhibits were presented by the departments of biology, chemistry, geology, and home economics. Dr. Edgar Paul Rothrock, State Geologist, spoke on "A Lost World of South Dakota." A nine-reel program of scientific movies and organized industrial tours occupied the afternoon. Over one thousand visitors, including more than three hundred high-school students from adjoining cities, attended.

Dwight L. Seybert, a chemistry major and graduate this month, has accepted a most attractive position with the Chicago, Milwaukee, St. Paul, and Pacific Railroad. He will make his headquarters at Mitchell, S. D., and his work will deal principally with water supply and use. He has been connected with this company in various other capacities for eleven years.

The fourth annual Chemistry and Home Economics Industrial Tour was held on April 15th. Seven industrial plants of Sioux Falls, S. D., were visited.

Carnegie Institute of Technology. A special program of recreation and entertainment for summer school students at the Carnegie Institute of Technology in Pittsburgh is already being planned, it is announced. In addition to the regular recreational features, such as the use of the Institute's swimming pool and tennis courts, popular lectures and inspection trips, plans for the coming summer include musical recitals, dances, picnics, receptions, an outdoor play, and other features.

Excursions and visits to the industrial plants and to various points of interest in the Pittsburgh District, a popular feature in former years, will again constitute an important part in the plans because of the special interest that the student or teacher of industrial processes naturally shows in such opportunities.

The Carnegie summer session will open June 17th for courses for teachers and supervisors of Music, Fine and Applied Arts, Industrial Education, and Psychology and Education, and for courses in engineering and industrial subjects for undergraduates.

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A record of the latest scientific developments in the improved utilization of bituminous coal as raw material is now available in the published proceedings of the Second International Conference on Bituminous Coal held at the Carnegie Institute of Technology in November, 1928.

The Proceedings are published in two volumes containing a total of 1927 pages of type matter and illustrations. The text is composed of 111 different manuscripts by some of the world's foremost fuel technologists, chemists and engineers, complete discussions by delegates, and a forty-page index. A majority of the papers are accompanied by illustrations.

That the Carnegie Institute of Technology is already making preliminary plans for a third international coal conference is indicated in the foreword by Dr. Thomas S. Baker, president of the Carnegie Institute of Technology and organizer of the first and second conferences. "The success of the Carnegie Congresses and the developments in fuel technology which may be expected in the future," according to his foreword, "encourage us to believe that another International Conference would be welcomed and would be of value." The Carnegie authorities, however, have not yet fixed a date for the third conference.

The second conference, according to the published proceedings, had a registration of about two thousand including delegates from twenty-two countries. The papers reproduced in the proceedings cover low-temperature distillation, origin, composition and classification of coal, use of pulverized fuel, fertilizers from coal, purification and cleaning of coal, power and combustion, liquefaction of coal, tar and oil from coal, gasification of coal, and high-temperature distillation.

Sigma Xi, University of Cincinnati. Following the custom inaugurated several years ago, members of the American Chemical Society, Daniel Drake Medical Society, and the Academy of Medicine, were guests of Sigma Xi, the Society for the Promotion of Research, at an illustrated lecture on Friday, May 3rd, in the auditorium of the Medical College.

Dr. Ellice McDonald, Chairman of the Cancer Research Fund, of the Graduate School of Medicine, University of Pennsylvania, spoke on "Cellular Division in Relation to Cancer," illustrated by four reels of motion pictures of living cells made by Professor Canti of London. Dr. McDonald, commenting on the films, said: "The film is of cell division on animal cells in tissue culture. It shows dividing cells, mitosis, Karyo Kinesis, and equatorial separation of the chromosomes. It also shows the effects of radium on cell division. It shows phagocytosis, mitichrondria, etc. There are two reels given over to dark field microscopy. It shows normal cells and cancer cells. It is applicable to biologists, medical men, botanists, cell physiologists, etc."

The Nebraska Academy of Sciences. The Nebraska Academy of Sciences met in Lincoln on May 3rd and 4th. The program of interest to chemistry teachers was as follows:

FRIDAY, 1.30 A.M.

B. CLIFFORD HENDRICKS, University of Nebraska, *Chairman*

1. "Oxidation of Sugar Acids under Varying Conditions," F. W. UPSON AND E. L. MATTISON, University of Nebraska.
2. "A Probable Cause of Variation of the Nitrogen Metabolism of Experimental Hens," C. W. ACKERSON, M. J. BLISH AND F. E. MUSSEHL, University of Nebraska.
3. "A Five-Minute Method for Moisture in Flour," M. J. BLISH AND BEN D. HITES, Agricultural College, University of Nebraska.

4. American Chemical Society Essay Contest—Teachers' College Essays.
   (*a*) "The Contribution of Chemistry to the Enrichment of Life," JOE JONES, Peru State Teachers' College.
   (*b*) "Chemistry of Oil Shales," ROBERT WHITTMORE, Peru State Teachers' College.
   (*c*) "The Relation of Chemistry to Health and Disease," SAM TRAUDT, Peru State Teachers' College.
5. "'Unknowns' in Qualitative Analysis," D. J. BROWN AND R. E. NICKELSON, University of Nebraska.
6. "Electromotive Force Measurement of the Permanganate Manganese Dioxide Electrode," D. J. BROWN AND L. V. ANDREWS, University of Nebraska.
7. "Oxidation of *d*-Glucose by Air in Saturated Barium Hydroxide Solution," F. W. UPSON AND C. W. EDDY, University of Nebraska.
8. "Temperature-Volume Changes on Mixing of Liquids," E. R. WASHBURN, University of Nebraska.

SATURDAY, 9.00 A.M.

ROYCE LE ROY, Doane College, Presiding

9. "The Specific Dynamic Action of Protein as Affected by Body Build," REBEKAH GIBBONS, University of Nebraska.
10. "The Vitamin Content of Liver from Hogs with Experimental Rickets," REBEKAH GIBBONS AND CHARLOTTE B. BARNEY, University of Nebraska.
11. "Improved Methods for Laboratory Preparations from the Organic Laboratory," Department of Chemistry, University of Nebraska.
    (*a*) "Malonic Acid," L. V. ANDREWS.
    (*b*) "Acetanilide and Homologs," R. NICKELSON.
    (*c*) "Benzylidene Aniline and Its Nitration Product," D. HAYMAN.
12. "Stereoisomerism in the Glutaric Acid Series," SAMUEL AVERY AND W. D. MACLAY, University of Nebraska.
13. "Brownian Movement as Seen through the Ultramicroscope," a demonstration, V. HNIZDA, University of Nebraska.
14. "The Relations of Temperature, Pressure and Diaphragm Thickness to the Diffusion Rate of Gases through Hot Metals," B. CLIFFORD HENDRICKS AND R. R. RALSTON, University of Nebraska.
15. "Chemistry of Bone," S. MORGULIS, University of Nebraska, College of Medicine.
16. "Effect of Parathyroids on the Calcium of the Blood," S. MORGULIS AND ANNE M. PERLEY, University of Nebraska, College of Medicine.

New England Association of Chemistry Teachers. The 116th Meeting of the N. E. A. C. T., was held on Saturday, May 18th, at Nashua High School, Nashua, N. H.

PROGRAM

Morning Session

10.00 Inspection of plant of Nashua Manufacturing Co., makers of Indian Head Blankets.

Afternoon Session

1.30 "Some Aspects of Chemical Equilibrium," GEORGE H. BURROWS, University of Vermont, Burlington, Vt.
2.15 "Association of Chemistry with a Few Practical Problems," OWEN MCGAFFIGAN, Instructor of Chemistry at the Revere High School, Revere, Mass.
2.45 Business meeting.

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The 117th Meeting was held on Saturday, May 25th, at Worcester Polytechnic Institute.

PROGRAM

10.00 Industrial trip to the Norton Co.
1.15 Address of welcome by President Ralph Earle.
1.30 Inspection of Swimming Pool, Alumni Gymnasium.
2.00 Inspection of Salisbury Chemical Laboratory. Senior and graduate students were present to explain and demonstrate apparatus used by them in research.

2.45 "Chemical Engineering Education," T. K. SHERWOOD.
3.15 "Sanitary Control of Swimming Pools," M. E. SMITH.
3.45 "Effect of Neutral Salts on Hydrogen-Ion Concentration," F. R. BUTLER.
4.15 Business meeting.

The Cincinnati Section, A. C. S. The 307th Meeting of the Cincinnati Section of the American Chemical Society was held in the auditorium of the Chemistry Building of the University of Cincinnati, on May 8th, at 8.00 P.M. Preceding the meeting, a "get-together" dinner was served.

The speaker of the evening meeting was Dr. Francis F. Heyroth of the University of Cincinnati College of Medicine. Dr. Heyroth received much of his early training at Ohio Mechanics Institute but holds his B.S. and M.D. degrees from the University of Cincinnati. His subject was: "Recent Investigations of Certain Proteins by the Aid of the Ultracentrifuge." Dr. Heyroth's address dealt chiefly with Svedberg's methods for determination of molecular weight of colloids by the aid of centrifugal force, the results so far obtained and the conditions under which certain of the molecules are stable.

Florida Section, A. C. S. The 23rd meeting of the Florida Section of the American Chemical Society was held at Gainesville on Saturday, May 11th, at the Chemistry-Pharmacy Building of the University of Florida.

The program for the afternoon session was in charge of the Faculty of the Florida State College for Women. It was as follows:

"The Place of Minute Traces of Minerals in Nutrition," REBECCA B. HUBBELL.

"The Present Status of Vitamin B," BEULAH WESTERMAN.

"Report of Nutrition Research at Florida State College for Women," JENNIE TILT.

The address of the evening was delivered by DR. T. Z. CASON, of the Riverside Hospital of Jacksonville. His subject was, "Some Clinical Phases of Hypothyroidism—Problems to Be Solved."

Lexington Section, A. C. S. The 135th regular meeting of the Lexington Section of the American Chemical Society was held in the Physics Lecture Room, University of Kentucky, Friday, May 17th, at 3.15 P.M.

Professor B. Smith Hopkins, professor of inorganic chemistry, University of Illinois, spoke on "The Rare Earths." Professor Hopkins exhibited samples of materials and illustrated his lecture with slides. The discoverer of "Illinium" also reported on recent work with this element.

Dr. J. G. Black exhibited a dynamic model of the sodium atom.

The annual election of officers took place at this meeting.

Stanford University. Professor Robert E. Swain, besides continuing with his duties as executive head of the chemistry department, is acting president of the university during the absence of President Wilbur as Secretary of the Interior.

Professor E. C. Franklin, Past President of the American Chemical Society, retires this year from active duty. A graduate fellowship, established by his friends and associates in his honor, is to be awarded for the first time for the coming college year. Professor Franklin left in April for an extended tour. After attending various scientific meetings in the east and spending a little time in Europe, he plans to attend the meeting of the British Association for the Advancement of Science in Capetown, South Africa, as the guest of that Association.

Another new graduate fellowship has been established here by the Shell Development Corporation, the terms of the fellowship being most liberal.

Professor James W. McBain recently returned from a trip to the eastern part of the country, attending the American Chemical Society meeting at Columbus and visiting a number of eastern and middle-western universities.

The Carnegie Institution is erecting on the campus a laboratory of experimental texonomy and genetics. The staff of this laboratory is to be headed by Dr. Herman A. Spoehr, the author of "Photosynthesis." We all hope to benefit greatly as a result of the expected close coöperation between the two laboratories.

Sixth Annual Contest, R. I. State College. The annual chemistry contests for students of Rhode Island high schools were started in 1924 and occur on the day of the Interscholastic Track Meet at Rhode Island State College. At this time about 1500 high-school pupils and their friends come to Kingston and there is great rivalry between different schools. The chemistry contest has helped to add considerable interest to the events of the day.

The purpose of the contests was primarily to interest high-school boys and girls in the science of chemistry and to afford a means of competition in some mental activity for those who might not have athletic ability. The contest has so far been limited to Rhode Island schools for several reasons and consequently the number of contestants has been rather small in number, about 50 to 60 for any one year.

Because the tests have to be corrected quickly in order to make the awards at the same time as the athletic medals are given out, the questions are of such a type that they are answered by drawing a line through the correct answer which is a choice of several given or by supplying missing words. Thus various modifications of the short-answer or new-type questions are employed. The questions are 100 in number and are valued on an equal basis, regardless of subdivision, except in case of a tie score. Last year illustrated questions were introduced.

There are numerous prizes for the high-standing contestants and souvenirs for all who participate in the contest. These prizes are contributed by friends of the department and add materially to the success of the affair. Books upon chemical topics, appropriate loose-leaf notebooks, slide rules, chem-rules, etc., are included in the list of individual prizes and a silver trophy goes to the high school having the winning team. If won three years in succession this trophy becomes the permanent property of the successful high school. The first trophy was won by the Pawtucket high school at the end of the fourth year.

The Sixth Contest attracted an entry of nine high schools and a total of 55 contestants. The highest scoring individual was John Suesman, of Cranston High School, with a score of 93.5%. The next two high scoring individuals were Joseph Dolan and John Dunn of LaSalle Academy (Providence), and it was this school which won the contest for this year.

Copies of the 1928 and 1929 test papers are available to all teachers who will send 10 cents in stamps to cover postage. The department is desirous of coöperating with teachers who will give this test to five of their best students and return the papers to Kingston for correction, on the understanding that the grades will be reported back to the teacher at as early a date as possible and that no publicity will be given names in connection with schools. The only other requirement in this plan is that the teacher will send in the request with 10 cents in stamps and then pay the cost of the postage when returning tests for correction.

Address all correspondence to Prof. J. W. Ince, head of the chemistry department, Rhode Island State College, Kingston, R. I.

American Institute of Chemists, Washington, D. C., Chapter. The Washington Chapter of the American Institute of Chemists met May 17th at the Cosmos Club. After a brief business meeting at which *Chairman* J. N. Taylor presided, a lecture on the employment relations of the government to the chemist was delivered by Mr. Fred Telford, who is an expert on personnel problems. He is also director of the Bureau of Public Personnel Ad-

ministration, which is a semi-public institution partly supported by the Rockefeller Foundation and partly by the U. S. and Canadian Civil-Service Commissions. Mr. Telford pointed out a number of faults in the government's personnel work, as, for example, one bureau recruits the personnel, another defines their classification and duties, still another passes on their efficiency, Congress fixes the rate of pay, the comptroller general has authority to set aside the decisions of all the others if he deems them in conflict with existing law and innumerable offices and bureaus not connected or correlated in any way have a finger in the personnel pie. The Bureau of the Budget notifies all executives that rigid economy must prevail and as a result some use various subterfuges to make a good showing. An instance was mentioned where a chemist who needed employment badly was induced to accept a position as lighthouse keeper and then given chemical work. No business located in Washington would advertise from Maine to Oregon for stenographers, messenger boys, and chemists and then refuse to accept applications from those living in its natural recruiting territory of the District of Columbia, Maryland, and Virginia. Such conditions make it difficult for the government to secure efficient service.

A suggested remedy is to centralize all the personnel work of the government in one department, with a cabinet officer, technical director, and various bureaus. A movement to accomplish this was recently started by the Institute for Government Research. Two classes of organizations have appointed delegates to coöperate in this movement but none of those attending the conferences were authorized to commit their organizations to any definite course of action. These classes are composed of various scientific personnel organizations and civic or labor groups interested in more efficient government, and include the National Municipal League, U. S. Chamber of Commerce, General Federation of Women's Clubs, American Federation of Labor, and about a dozen other widely known organizations. Those attending the meetings were in almost unanimous agreement that the existing organization for handling the government's personnel problems is inefficient and inadequate. A plan for creating a department of administration combining under one authority the many agencies and bureaus now existing has been worked out and will be submitted to President Hoover.

When the U. S. Personnel Classification Board made its allocations, it placed the librarians in clerical positions. The librarians claimed that their work was professional. To prove it they secured the services of the Bureau of Public Personnel Administration to work out for them a comprehensive and scientific statement of the duties, qualifications, criterions and compensations logically applying to the different classes of librarians. This was published in book form and the classification board adopted the scheme in large part as it was presented, thus giving the librarians 90% of all the demands they had previously refused. This work has since been used by librarians all over the country to back up their claims for more satisfactory examinations for employment, better working conditions and higher salaries.

Chemists have never mobilized their forces to advise with those desiring to improve their conditions. We say the aim of this Institute is to raise the educational and wage standards of the chemist but technical personnel agencies are unable to discover after much work what the present standards are. We need a detailed statement of our ideas and ideals, of what the various kinds of chemical work consist, of the mental and educational qualifications and experience necessary for their proper performance, of how these qualifications can be measured best, and of the compensations proper for qualified persons doing each type and grade of work. Such a statement if based on a scientific and thorough-going job would be invaluable to

chemists everywhere in securing legislation, in making contracts and in seeking improved working conditions or salaries. To make such a study properly will require the expenditure of about $20,000, and the active coöperation of a representative proportion of the chemists of the country in securing the necessary data. It is believed that one of the educational foundations would be willing to finance the task if seriously undertaken by the American Institute of Chemists.

Virginia Academy of Science. The seventh annual meeting of the Virginia Academy of Science was held at Staunton Military Academy, Staunton, Va., May 10th and 11th. Sixty-five papers were presented, distributed among the different sections as follows: section of astronomy, mathematics, and physics, 18; section of biology, 13; section of geology, 9; section of psychology and education, 8; section of chemistry, 10; section of bacteriology, 7.

The following resolutions were adopted: (1) that the Virginia Academy of Science protests against a higher duty on scientific apparatus and urges the restoration of the former privilege of duty-free importation on scientific supplies for educational and research institutions; (2) that an international conference be called, the United States participating, to consider the calendar question without being committed to any special principle of revision.

A paper of unusual interest to chemistry teachers was presented by Dr. R. A. BAKER of the University of Syracuse, N. Y., on "Building upon the High-School Chemistry Course."

The annual research prize of $50 was awarded to Mr. J. C. Street, a graduate student in physics at the University of Virginia, whose topic was "The Time Lag of the Spark Discharge."

The following officers were elected for the coming year: *President*, DR. GARNETT RYLAND, professor of chemistry, University of Richmond, Richmond, Va.; *secretary*, DR. E. C. L. MILLER, Medical College of Virginia, Richmond, Va.; *councilor*, DR. L. R. GEISSLER, Randolph Macon Woman's College, Lynchburg, Va.

The next meeting will be held with Randolph Macon Woman's College, Lynchburg, May, 1930.

Information on Aluminum. A group of four interesting pamphlets on the uses and properties of aluminum have just come to hand from the British Aluminum Co. "Aluminum Chemical Plant" is a reprint of a lecture given on the subject by Mr. E. T. Painton, at the Sir John Cass Technical Institute, which was reported in *The Chemical Age* of December 1, 1928 (pp. 510–2). "The Lightest of Common Metals" is a group of interesting photographs of the varied products into the manufacture of which aluminum enters, ranging from flying boats and racing cars to portable typewriters and bathroom fittings. "Aluminum Bronze" gives a very interesting and compact account (76 pp.) of this interesting substance, dealing with the foundry technic, the influence of other metals, heat treatment, notes on die-casting, wrought alloys, etc. It is addressed to those who are attracted to the obvious possibilities of aluminum bronze, and who fear its pitfalls. It is pointed out that we stand as a nation much in regard to aluminum bronze as we do to many similar advances in metallurgical science. That is to say, while retaining a lead in fundamental research, we have left the practical application of that research largely to foreign enterprise, notably American. A number of concerns in this country have, however, done valuable pioneer work and established thriving industries in this material.

The fourth pamphlet deals with "Aluminum Sheet Metal Work."—*Chem. Age* (*Mo. Metallurgical Section*), **20**, 21 (Mch. 2, 1929).

Recent Books

The Nature and Meaning of Teaching. RALPH H. STREBEL, Asst. Prof. of Education, and GROVER C. MOREHART, Assoc. Prof. of Education, Teachers' College, Syracuse University. McGraw-Hill Book Company, Inc., New York City, 1929. xix + 273 pp. 20 figures. 20.5 × 14 cm. $2.50.

Primarily this is a text on "general methods"—those methods that apply always in the management of pupils and in the teaching of all subjects. In the preface we read: "The sole purpose in writing this volume has been to attack the problem of the technic of teaching from a different point of view from any extant."

The newness in the point of view (strange as this may seem to scientists) lies in the fact that the authors present their suggestions as to the teaching practice in terms of educational philosophy and educational psychology. They feel that students of education should not only be told what to do but why, in order that they may be able to adapt procedure to varying conditions.

The text opens with a chapter on the development of educational philosophy from the time of Socrates. Then follows a second chapter on modern aims and objectives in education, with a third chapter on educational psychology and Thorndike's "Laws of Learning." After this comes the discussion of teaching problems and practices with constant use and application of the principles laid down in the opening chapters. The result is a synthesis of educational philosophy, psychology, and practice, in a unified, fundamental, beginning course. The title "General Education" would not be an inappropriate one for such a course or for the text that is being reviewed.

JOHN W. RITCHIE

FLEMINGTON, NEW JERSEY

Enriched Teaching of Science in the High School. M. N. WOODRING, Associate Professor of Education, Teachers' College, Columbia University; M. E. OAKES, Assistant in Natural Sciences, Teachers' College, Columbia University; H. E. BROWN, Teacher of Science, Lincoln School, Teachers' College, Columbia University. Bureau of Publications, Teachers' College, Columbia University, New York City, 1928. xi + 374 pp. 23 × 15.5 cm. $2.75.

The authors of this book offer to teachers of science sources of supplies from which they can enrich their teaching and promote interest in their work. Their intention is to list material that can be obtained free or at a low price, or that has real value at the quoted prices.

Many of the articles that can be obtained free from manufacturers partake of the nature of advertising, so the teacher is warned that he must be the judge of its worth and also of the correctness of the advertising. The authors state, however, that they have examined, or had others examine, the materials listed and have endeavored to cull out that which had little or no value.

The work is intended for teachers of general science, biology, physics, and chemistry. Chemistry has received its full share of attention. The materials are arranged under sixteen different headings, which include: models, samples, exhibits, pictures, posters, charts, lantern slides, motion pictures, equipment, supplies, lectures, catalogs, plays, clubs, projects, excursions, careers, schools, travel, camps, professional associations, tests, vocabularies, elementary science, pamphlets, periodicals, magazines, and books. Under these headings there are two or three thousand separate items.

Since this book is the first of its kind on

the market and covers such a vast array of material, science teachers will find it valuable. It will be particularly useful to teachers in the smaller schools where there is little manufacturing and where the school equipment is poor for science work.

A source of good material, not listed by the authors, is scientific articles in the non-professional magazines. Much time is wasted in reading articles having little value to science teachers, although perhaps written by college professors. Possibly ten or fifteen articles of exceptionally high rank appear in these general magazines each year. A listing of these articles, culled to the limit, five or more years back would be appreciated by teachers having no access to good libraries or by others who do not wish to search the large number of periodicals for the few good articles.

The authors have done a commendable work in compiling the information in this book. In the hands of any teacher, it should enrich the courses in high-school science.

DON C. EVANS

PARK COUNTY HIGH SCHOOL,
LIVINGSTON, MONTANA

History of Recent Chemistry (in the Japanese language). ROKURO NAKASEKO. Kaniya Book Store, Kyoto, 1927. 14.5 × 21.5 cm. iii + 561 pp. 16 photogravure portraits. 6 yen.

This is a companion volume to Professor Nakaseko's "History of World Chemistry" [see THIS JOURNAL, **6**, 184 (Jan., 1929)] and consists of a further detailed account of the history of such special subjects as the chemistry of the life processes, proteins and fats, the fixation of nitrogen, the electric furnace, organic synthesis, catalysis, chemical warfare, explosives, silk and artificial silk, photography, dyestuffs, pharmaceutical chemistry, immunity, the rare elements which are present in living organisms, etc. The discussions in each case are excellent and take account of the latest developments. The book contains much material which has not heretofore been brought together in a single volume.

It is beautifully arranged and illustrated. A splendid artistic touch is given by the inclusion, after the title page, of two pages of *written* Chinese—a section from Pao Pu Tzŭ (written by Ko Hung, 281–361 A.D.)—"Many do not even know that mercury comes out of cinnabar (tan sha). When told, they still refuse to believe it, saying that cinnabar is red, and how can it produce a white substance? They also say that cinnabar is a stone—that stones when heated turn to ashes; and how then can anything else be expected of *tan sha*." (trans. Edkins). This quotation, from one of the oldest treatises on alchemy, gives us a perfect suggestion of the mystery of chemistry and of that quality in the history of chemistry which makes its study so fascinating to those who are devoted to it.

My thanks are due to Mr. Lu-Ch'iang Wu, graduate student at the Massachusetts Institute of Technology, for translating the chapter headings and the section of Pao Pu Tzŭ.

TENNEY L. DAVIS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
CAMBRIDGE, MASS.

Moderne Methoden der Kohlenverwertung. Ferngas and Kohleverflüssigung. (Modern Methods of the Utilization of Coal. "Fern gas" and Liquefaction of Coal.) HERMANN GROSSMANN, Professor in the University of Berlin. Polytechnische Buchhandlung. A. Seydel, Berlin, 1928. 16 pp. 1 fig. 15 × 22 cm. 1 mark.

The pamphlet is a reprint of two speeches broadcast by the author on the 18th and 25th of November, 1927.

The first speech deals with "Fern gas." This is waste coke oven gas which is piped from the large reserves of the Ruhr plants to distant communities and center of industries in Germany. The following pipe lines are planned: (1) Bremen, Hamburg, Lübeck, Kiel; (2) Hanover, Magdeburg, Berlin, Stettin; (3) Kassel, through Thuringia, Saxonia, Silesia; (4) along the

Rhine, through Hessia, Baden, Württenberg, and Bavaria. The author lists the following advantages and disadvantages of the project. *Advantages:* (1) The plan does away with a large number of local gas plants; (2) the price of the gas will not be subject to market fluctuations; (3) the number of workmen employed by the cities can be decreased. *Disadvantages:* (1) The independence of the community will be decreased; (2) in the case of strikes there is always a chance of damages being done to long pipe lines; (3) numerous consumers will not be able to purchase coke cheaply from the local gas plants; (4) the income of the railways will be diminished due to the decrease in transportation of coke and coal.

The second speech deals with the history of the liquefaction of coal, the development of synthetic fuel, and the various processes involved.

The author states no figures whatever. It would have been interesting if, for example, he could have made an estimate of the cost of installing such a piping system. Nevertheless, he gives an excellent review of a subject which is of as great economic importance as the synthesis of ammonia.

LEOPOLD SCHEFLAN

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BROOKLYN, N. Y.

Science for the Home Manager. A series of fourteen radio talks sponsored by MELLON INSTITUTE OF INDUSTRIAL RESEARCH. With a Foreword by L. W. BASS, Ph.D., *Executive Assistant*, Mellon Institute. *Radio Publication No. 48*, University of Pittsburgh, Pittsburgh, Pa., 1929. 138 pp. 22 × 15.5 cm. $0.75.

The series of talks included in this booklet give a general idea of the recent developments in household economics resulting from the application of the scientific method to domestic problems. The talks were delivered by recognized specialists in the various fields covered. The preparation of this series was prompted by one of the guiding principles of the Mellon Institute, namely, "the dissemination of scientific information which may be applied in daily life."

A glance at the chapter headings is significant of the interest they hold:

Science and the Home, GEORGE D. BEAL
Soap, the Agent of Cleanliness, R. B. TRUSLER
Extermination of Pests, O. F. HEDENBURG
The Selection of Bedding Equipment, H. M. JOHNSON
The Care of the Bedroom, T. H. SWAN
Foods That Are Most Healthful, E. R. HARDING
Carpets and Draperies, L. E. JACKSON
Selection and Care of Kitchen Equipment, ERICH W. SCHWARTZE
Plants for the Home, O. E. JENNINGS
Heating of the Home, R. H. HEILMAN
Healthful Ventilation, R. H. HEILMAN
When Painting Is Needed, H. K. SALZBERG
Fire Risks and Prevention, H. S. COLEMAN
Residential Roofings, HENRI MARC

M. W. G.

The Use of Scales for Rating Pupils Answers to Thought Questions. *Bulletin No. 46*, Bureau of Educational Research, University of Illinois. C. W. ODELL, Ass't Director, Univ. of Ill., Urbana, Ill. May 7, 1929. 34 pp. 15.5 × 23 cm. $0.50.

In *Chapter I* we find a statement of the problem under investigation. *Chapter II* contains a rather detailed account of the construction of the scales and the carrying on of the investigation. *Chapter III* presents the statistical results from the standpoint of comparing ratings with the scales to ratings without them and attempts to analyze these data, comparing them with similar data reported by others for English composition scales. *Chapter IV* contains a brief summary and the general conclusions drawn from the investigation. In *Appendix A* is found the complete list of questions used in the scales. *Appendix B* presents data from ratings of sets of pupils' answers rather than from single answers, and briefly discusses the reliability of traditional examinations.

M. W. G.

Bibliographic Series of Mellon Institute of Industrial Research. Second Supplement to *Bulletin* No. 2. LOIS HEATON. Pittsburgh, Pa., 1928. 11 pp. Free.

This publication lists 1 book, 14 bulletins, 15 research reports, 104 other scienti-

fic and technical papers, and 25 U. S. patents which were published during the year 1928. Copies of this *Supplement* will be sent to any chemists, librarians or teachers requesting it.

Abstracts of Scientific and Technical Publications from the Massachusetts Institute of Technology. Number 3. The Technology Press, Cambridge, Mass., 1929. 43 pp. 23 × 15 cm.

BOOKS RECEIVED—LIBRARY OF CONGRESS, APRIL 15 TO MAY 15, 1929

Bary, Paul, Chimie des colloïdes, applications industrielles; conférences faites au Conservatoire des arts et métiers du 16 au 25 mai 1928. Paris, Dunod, 1929. viii, 132 pp., illus. 21½ cm.

Béthencourt, Arthur Octave Constant, Chimie, classe de première. Paris, Hachette, 1928. 2 pp. l., 218, 2 pp., illus. (incl. maps) diagrs. 18½ cm.

Blackie, Alfred, The Thomas recording gas calorimeter. London, H. M. Stationery Off., printed by Harrison and Sons, Ltd., 1928. vi, 42 pp. incl., illus., tables, diagr. 24½ cm.

Bronsted, Johannes Nicolaus, Om syre- og basekatalyse. København, B. Lunos Bogtrykkeri, 1926. 120 pp. 25 cm.

Chávez, M. Julio, Contribución al estudio del thiosulfato de sodio. Santiago, Imprenta "San Pablo," 1928. 31, 1 p. incl. tables. 25½ cm.

Compagnoni, Giuseppe, La chimica per le donne. Venezia, Dalla tip. di A. Curti, presso Giustin Pasquali q. Mario, 1797. 2 v. in 1. 20 cm.

Contreras, T. Rafaela, Ultimos procedimientos empleados para análisis de agua. Santiago, Imprenta "San Pablo," 1928. 24 pp. 26 cm.

Coons, Charles Curtis, Thermal transpiration and thermal dissociation in iodine and bromine vapors. Urbana, Ill., 1928. 12 pp. 23 cm. Abstract of thesis (PH.D.)—University of Illinois, 1928.

Crawford, Helen Marjorie, The reaction between duroquinone and the Grignard reagents, Easton, Pa., 1928. 869–883 pp. diagrs. 23 cm. Thesis (PH.D.)—University of Minnesota, 1927.

Fletcher, Gustav Ludwig, Herbert O. Smith, and Benjamin Harrow, Beginning chemistry. New York, Cincinnati, etc. American Book Company, 1929. viii, 476 pp. col. front., illus. (incl. ports.) col. pl., diagrs. 21½ cm.

Gilman, Elizabeth, and Treat B. Johnson, The synthesis of mesoxalates by interaction of nitrogen tetroxide with esters of malonic acid. Easton, Pa., 1928. 3341–3348 pp. 23½ cm.

"Constructed from a dissertation presented by Elizabeth Gilman in June, 1927, to the faculty of the Graduate school of Yale University in partial fulfilment of the requirements for the degree of doctor of philosophy."

Goldman, Frederick Herbert, The activity coefficients of lanthanum and thallous iodates in aqueous salt solutions. New York City, 1928. 27, 1 p., 1 l. diagrs. 23 cm. Thesis (PH.D.)—Columbia University, 1928.

Harper, Robert Brinton, Problems of the gas industry. Lafayette, Ind., Purdue University, 1928. 20 pp. 22½ cm.

Johnson, Obed Simon, A study of Chinese alchemy. Shanghai, China, 1928. 3 pp. l., v–xi pp., 1 l., 156 pp. 21 cm. Thesis (PH.D.)—University of California, 1925.

Kleinheksel, J. Harvey, Observations on the rare earths: The preparation and properties of some anhydrous rare earth chlorides. Easton, Pa., 1928. 1 p., l., pp. 959–967, 1 l. illus., diagr. 23½ cm. Abstract of thesis (PH.D.)—University of Illinois, 1927.

Larmour, Ralph Kenneth, A comparative study of the glutelins of the cereal grains. Washington, D. C., 1928.

Cover-title, pp. 1091–1120. 23 cm. Thesis (PH.D.)—University of Minnesota, 1927.

Lazzell, Charles Lester, Solubility relations of isomeric organic compounds. VIII. Solubility of the aminobenzoic acids in various liquids. Ithaca, N. Y., 1928. 1331–1341 pp., diagrs. 26½ cm. "From a part of the dissertation presented to the Graduate School of Yale University, in June, 1927, by Charles L. Lazzell in candidacy for the degree of doctor of philosophy."

Lehner, Sigmund, Die imitationen. Eine anleitung zur nachahmung von natur- und kunstproducten, als: elfenbein, schildpatt, perlen und permutter . . . sowie zur anfertigung von kunst-steinmassen, nachbildungen von holzschnitzereien, bildhauer-arbeiten, mosaïken, intarsien u. s. w., für gewerbetreibende und künstler. Wien etc., A. Hartleben, 1883. 3 p. l., 256 pp., illus. 18½ cm.

Lehner, Sigmund, Die tinten-fabrikation und die herstellung der hektographen und hektographirtinten; die fabrikation der tusche, der tintenstifte, der stempeldruckfarben, sowie des waschblaues. Ausführliche darstellung der anfertigung aller schreib-, comptoir-, copir- und hektographirtinten. . . nebst einer anleitung zum lesbarmachen alter schriften. Wien etc., A. Hartleben, 1899. 1 p. l., viii, 245 pp., illus. 18½ cm.

Manning, Alexander Bernard, J. G. King, and F. S. Sinnatt, The "unsaturated hydrocarbons" in the gases from the carbonization of coal. London, H. M. Stationery Off., printed by Harrison and Sons, Ltd., 1928. iv, 19 pp. incl. illus., tables, diagrs. 24½ cm.

Massoulier, Pierre, Chimie à l'usage des élèves des classes de seconde A, A′ et B. Paris, Vuibert, 1927–29. 2 v. illus., diagrs. 19 cm.

McLaughlin, Henry Max, The effect of pressure on the decomposition of potassium chlorate in the presence of manganese dioxide. Easton, Pa., 1928. 13 pp., 1 illus., diagrs. 26 cm. Thesis (PH.D.)—Iowa state college of agriculture and mechanic arts, 1924.

Müller, Emil, Chemie und patentrecht. Berlin, Verlag Chemie, g. m. b. h., 1928. 127 pp. 24 cm.

Neckers, James Winfred, Observations on the rare earths: I. Fractional precipitation of the cerium group earths by electrolysis. II. Solubility of rare earths oxalates in nitric acid. III. Separation of cerium. Easton, Pa., 1928. 1 p. l., pp. 950–958, 1 l. 23½ cm. Abstract of thesis (PH.D.)—University of Illinois, 1927.

Nicoll, William Dickson, Mechanism of carbohydrate oxidation: the oxidation of *d*-galactose by saturated copper acetate solutions. Columbus, 1928. 23, 1 p. diagrs. 24½ cm. Thesis (PH.D.)—Ohio State University, 1927.

Papesch, Otto, Reifung von bromsilbergelatine mit ammoniak und ammoniumkarbonat. Halle (Saale) W. Knapp, 1928. 2 pp. l., 32 pp. diagrs. 21½ cm.

Pierce, Jerry Albert, A study of the reaction between nitric oxide and hydrogen sulfide. Baltimore, 1928. 17, 1 p. illus., diagr. 26½ cm. Thesis (PH.D.)—Johns Hopkins University, 1928.

Ponder, Eric Haldane, Essentials of general physiology. New York, London, etc. Longmans, Green and Co., 1929. vii p., 1 l., 497 pp., illus., diagrs. 21½ cm.

Reuss, Eric Wilfred, I. Synthetische versuche auf dem gebiet des dalmatinischen insektenpulvers (pyrethrum). II. Eine neue klasse organischer kolloide: eukolloide salze aus kautschuk und guttapercha. Weida i. Thür., Druck von Thomas & Hubert, 1926. 78 pp., 1 l. 23½ cm.

Rinde, Herman, The distribution of the sizes of particles in gold sols prepared according to the nuclear method. Uppsala, Almqvist & Wiksells Boktryckeri-a.-b., 1928. 2 pp., l., 226 pp., 1 l. incl. illus., tables, diagrs. 25½ cm.

Roberts, Elliott John, The antimony-antimony trioxide electrode and its use as a measure of acidity. Easton, Pa., 1928. Cover-title, pp. 2125–2147. 1 illus. 23½ cm.

"From the dissertation presented by E. J. Roberts to the Graduate School of Yale University, June, 1928, in candidacy for the degree of doctor of philosophy."

Rodriguez, L. Inés, Estudio sobre la ionona y productos intermedios. Santiago de Chile, Escuela tip. salesiana "La Gratitud nacional," 1928. 25 pp. 25½ cm.

Ropp, Clarence Daniel Luther, A study of the system lithium perchlorate and water. Easton, Pa., 1928. 1650–1653 pp., diagr. 23½ cm. Thesis (PH.D.)—New York University, 1925.

Silverman, Alexander, Study questions and problems in inorganic chemistry. New York, D. Van Nostrand Company, Inc., 1928. vi, 97 pp. 24 cm.

Smith, Gertrude L., Spots and stains and how to remove them. New York, Delineator, 1929. 28 pp., illus. 23 cm.

Smith, Stanley, The cellulose lacquers; a practical handbook on their manufacture. London, New York, etc. Sir I. Pitman & Sons, Ltd., 1928. ix, 145 pp., incl. front., illus. 22 cm.

Swietoslawski, Wojciech, Thermochemie; arbeitsmethoden und analyse der thermochemischen daten insbesondere in dem gebiete der organischen verbindungen. Leipzig, Akademische verlagsgesellschaft m. b. h., 1928. xi, 253 pp., illus. 25 cm.

Taylor, Frank Sherwood, Elementary practical physical chemistry. Oxford, The Clarendon Press, 1928. xi, 130 pp., 1 l., illus., diagrs. 19 cm.

Thoms, Hermann Friedrich Maria, Grundzüge der pharmazeutischen und medizinischen chemie. Berlin, J. Springer, 1927. viii, 639, 1 p., illus. 24 cm.

Verdugo Young, Esperanza, El alquitran de hulla y sus materias colorantes. Santiago de Chile, Escuela tip. Salesiana "La Gratitud nacional," 1928. 20 pp., 2 l. 26½ cm.

Washburne, Robert Niles, Black body radiation and the decomposition of nitrogen pentoxide in molecular beams. Baltimore, 1928. 1 p. l., 1, 2402–2412 pp., 1 l., illus. 23½ cm. Thesis (PH.D.)—Johns Hopkins University, 1928.

Wilson, Stanley Davis, The effect of neutral salts on the velocity of saponification of ethylacetate by sodium hydroxide. Easton, Pa., 1928. 1 p. l., pp. 1250–1254. 23½ cm. Thesis (PH.D.)—University of Chicago, 1916.

. . . . . .

Carrier Engineering Corporation, Drying and processing of materials by means of conditioned air; a treatise for manufacturers, engineers, and students—an illustrated discussion of the many interesting problems involved in the drying and processing of numerous familiar materials, under controlled conditions of temperature, humidity, and air movement. Based on investigations by the research department of Carrier Engineering Corporation; edited by D. C. Lindsay, Newark, N. J., Carrier Engineering Corporation, 1929. 1 p. l., pp. 5–208, 2 l. illus. diagrs. 23½ cm. $3.00.

Swift & Company, *Library,* General reference sources to chemical and physical literature 1926, compiled by the librarian. Chicago, 1927. 30 numb. l. 27½ × 21 cm.

An idea isn't worth much until a man is found who has the energy and ability to make it work.

TABLE V

A PERIODIC CLASSIFICATION OF THE ELEMENTS ACCORDING TO STRUCTURE

1	2	3	4	5	6	7	8
1 H 1.0077 *K-1*							2 He 4 *K-2*
3 Li 6.939 *K-2* *L-1*	4 Be 9.02 *K-2* *L-2*	5 B 10.82 *K-2* *L-3*	6 C 12 *K-2* *L-4*	7 N 14.008 *K-2* *L-5*	8 O 16 *K-2* *L-6*	9 F 19 *K-2* *L-7*	10 Ne 20.2 *K-2* *L-8*
11 Na 22.997 *K-2* *L-8* *M-1*	12 Mg 24.32 *K-2* *L-8* *M-2*	13 Al 26.96 *K-2* *L-8* *M-3*	14 Si 28.06 *K-2* *L-8* *M-4*	15 P 31.024 *K-2* *L-8* *M-5*	16 S 32.065 *K-2* *L-8* *M-6*	17 Cl 35.458 *K-2* *L-8* *M-7*	18 A 39.91 *K-2* *L-8* *M-8*
19 K 39.095 *K-2* *L-8* *M-8* *N-1*	20 Ca 40.07 *K-2* *L-8* *M-8* *N-2*	21 Sc 45.1 *K-2* *L-8* *M-8* *N-3*					
	Ti *K-2* *L-8* *M-10* *N-2*	Ti *K-2* *L-8* *M-9* *N-3*	22 Ti 47.9 *K-2* *L-8* *M-8* *N-4*				
	V *K-2* *L-8* *M-11* *N-2*	V *K-2* *L-8* *M-10* *N-3*	V *K-2* *L-8* *M-9* *N-4*	23 V 50.96 *K-2* *L-8* *M-8* *N-5*			
	Cr *K-2* *L-8* *M-12* *N-2*	Cr *K-2* *L-8* *M-11* *N-3*			24 Cr 52.01 *K-2* *L-8* *M-8* *N-6*		
	Mn *K-2* *L-8* *M-13* *N-2*		Mn *K-2* *L-8* *M-11* *N-4*		Mn *K-2* *L-8* *M-9* *N-6*	25 Mn 54.93 *K-2* *L-8* *M-8* *N-7*	
	26 Fe 55.84 *K-2* *L-8* *M-14* *N-2*	Fe *K-2* *L-8* *M-13* *N-3*	Fe *K-2* *L-8* *M-12* *N-4*		Fe *K-2* *L-8* *M-10* *N-6*		
	Co *K-2* *L-8* *M-15* *N-2*	27 Co 58.97 *K-2* *L-8* *M-14* *N-3*	Co *K-2* *L-8* *M-13* *N-4*				
	Ni *K-2* *L-8* *M-16* *N-2*	Ni *K-2* *L-8* *M-15* *N-3*	28 Ni 58.69 *K-2* *L-8* *M-14* *N-4*				
29 Cu 63.57 *K-2* *L-8* *M-18* *N-1*	Cu *K-2* *L-8* *M-17* *N-2*						
	30 Zn 65.38 *K-2* *L-8* *M-18* *N-2*	31 Ga 69.72 *K-2* *L-8* *M-18* *N-3*	32 Ge 72.38 *K-2* *L-8* *M-18* *N-4*	33 As 74.96 *K-2* *L-8* *M-18* *N-5*	34 Se 79.2 *K-2* *L-8* *M-18* *N-6*	35 Br 79.916 *K-2* *L-8* *M-18* *N-7*	36 Kr 82.9 *K-2* *L-8* *M-18* *N-8*
37 Rb 85.44 *K-2* *L-8* *M-18* *N-8* *O-1*	38 Sr 87.62 *K-2* *L-8* *M-18* *N-8* *O-2*	39 Y 89 *K-2* *L-8* *M-18* *N-8* *O-3*	40 Zr 91 *K-2* *L-8* *M-18* *N-8* *O-4*	41 Cb 93.1 *K-2* *L-8* *M-18* *N-8* *O-5*	42 Mo 96 *K-2* *L-8* *M-18* *N-8* *O-6*	43 —	
	44 Ru 101.7 *K-2* *L-8* *M-18* *N-14* *O-2*	Ru *K-2* *L-8* *M-18* *N-13* *O-3*	Ru *K-2* *L-8* *M-18* *N-12* *O-4*		Ru *K-2* *L-8* *M-18* *N-10* *O-6*	Ru *K-2* *L-8* *M-18* *N-9* *O-7*	Ru *K-2* *L-8* *M-18* *N-8* *O-8*
	Rh *K-2* *L-8* *M-18* *N-15* *O-2*	45 Rh 102.91 *K-2* *L-8* *M-18* *N-14* *O-3*	Rh *K-2* *L-8* *M-18* *N-13* *O-4*		Rh *K-2* *L-8* *M-18* *N-11* *O-6*		
	Pd *K-2* *L-8* *M-18* *N-16* *O-2*	Pd *K-2* *L-8* *M-18* *N-15* *O-3*	46 Pd 106.7 *K-2* *L-8* *M-18* *N-14* *O-4*				
47 Ag 107.88 *K-2* *L-8* *M-18* *N-18* *O-1*	48 Cd 112.41 *K-2* *L-8* *M-18* *N-18* *O-2*	49 In 114.8 *K-2* *L-8* *M-18* *N-18* *O-3*	50 Sn 118.7 *K-2* *L-8* *M-18* *N-18* *O-4*	51 Sb 121.77 *K-2* *L-8* *M-18* *N-18* *O-5*	52 Te 127.5 *K-2* *L-8* *M-18* *N-18* *O-6*	53 I 126.932 *K-2* *L-8* *M-18* *N-18* *O-7*	54 Xe 130.2 *K-2* *L-8* *M-18* *N-18* *O-8*
55 Cs 132.81 *K-2* *L-8* *M-18* *N-18* *O-8* *P-1*	56 Ba 137.37 *K-2* *L-8* *M-18* *N-18* *O-8* *P-2*	57 La 138.91 *K-2* *L-8* *M-18* *N-18* *O-8* *P-3*					
	Rare Earths	58–71 Rare Earths *K-2* *L-8* *M-18* *N-18 to 32* *O-8* *P-3*	Rare Earths				
			72 Hf (178.6) *K-2* *L-8*	73 Ta 181.5 *K-2* *L-8*	74 W 184 *K-2* *L-8*	75 —	

	Zn 65.38 *K-2* *L-8* *M-18* *N-2*	Ga 69.72 *K-2* *L-8* *M-18* *N-3*	Ge 72.38 *K-2* *L-8* *M-18* *N-4*	As 74.96 *K-2* *L-8* *M-18* *N-5*	Se 79.2 *K-2* *L-8* *M-18* *N-6*	Br 79.916 *K-2* *L-8* *M-18* *N-7*	Kr 82.9 *K-2* *L-8* *M-18* *N-8*
37 Rb 85.44 *K-2* *L-8* *M-18* *N-8* *O-1*	38 Sr 87.62 *K-2* *L-8* *M-18* *N-8* *O-2*	39 Y 89 *K-2* *L-8* *M-18* *N-8* *O-3*	40 Zr 91 *K-2* *L-8* *M-18* *N-8* *O-4*	41 Cb 93.1 *K-2* *L-8* *M-18* *N-8* *O-5*	42 Mo 96 *K-2* *L-8* *M-18* *N-8* *O-6*	43 —	
	44 Ru 101.7 *K-2* *L-8* *M-18* *N-14* *O-2*	Ru *K-2* *L-8* *M-18* *N-13* *O-3*	Ru *K-2* *L-8* *M-18* *N-12* *O-4*		Ru *K-2* *L-8* *M-18* *N-10* *O-6*	Ru *K-2* *L-8* *M-18* *N-9* *O-7*	Ru *K-2* *L-8* *M-18* *N-8* *O-8*
	Rh *K-2* *L-8* *M-18* *N-15* *O-2*	45 Rh 102.91 *K-2* *L-8* *M-18* *N-14* *O-3*	Rh *K-2* *L-8* *M-18* *N-13* *O-4*		Rh *K-2* *L-8* *M-18* *N-11* *O-6*		
	Pd *K-2* *L-8* *M-18* *N-16* *O-2*	Pd *K-2* *L-8* *M-18* *N-15* *O-3*	46 Pd 106.7 *K-2* *L-8* *M-18* *N-14* *O-4*				
47 Ag 107.88 *K-2* *L-8* *M-18* *N-18* *O-1*	48 Cd 112.41 *K-2* *L-8* *M-18* *N-18* *O-2*	49 In 114.8 *K-2* *L-8* *M-18* *N-18* *O-3*	50 Sn 118.7 *K-2* *L-8* *M-18* *N-18* *O-4*	51 Sb 121.77 *K-2* *L-8* *M-18* *N-18* *O-5*	52 Te 127.5 *K-2* *L-8* *M-18* *N-18* *O-6*	53 I 126.932 *K-2* *L-8* *M-18* *N-18* *O-7*	54 Xe 130.2 *K-2* *L-8* *M-18* *N-18* *O-8*
55 Cs 132.81 *K-2* *L-8* *M-18* *N-18* *O-8* *P-1*	56 Ba 137.37 *K-2* *L-8* *M-18* *N-18* *O-8* *P-2*	57 La 138.91 *K-2* *L-8* *M-18* *N-18* *O-8* *P-3*					
	Rare Earths	58–71 Rare Earths *K-2* *L-8* *M-18* *N-18 to 32* *O-8* *P-3*	Rare Earths				
			72 Hf (178.6) *K-2* *L-8* *M-18* *N-32* *O-8* *P-4*	73 Ta 181.5 *K-2* *L-8* *M-18* *N-32* *O-8* *P-5*	74 W 184 *K-2* *L-8* *M-18* *N-32* *O-8* *P-6*	75 —	
	76 Os 190.8 *K-2* *L-8* *M-18* *N-32* *O-14* *P-2*	Os *K-2* *L-8* *M-18* *N-32* *O-13* *P-3*	Os *K-2* *L-8* *M-18* *N-32* *O-13* *P-4*		Os *K-2* *L-8* *M-18* *N-32* *O-10* *P-6*		Os *K-2* *L-8* *M-18* *N-32* *O-8* *P-2*
	Ir *K-2* *L-8* *M-18* *N-32* *O-15* *P-2*	77 Ir 193.1 *K-2* *L-8* *M-18* *N-32* *O-14* *P-3*	Ir *K-2* *L-8* *M-18* *N-32* *O-13* *P-4*				
	Pt *K-2* *L-8* *M-18* *N-32* *O-16* *P-2*	Pt *K-2* *L-8* *M-18* *N-32* *O-15* *P-3*	78 Pt 195.23 *K-2* *L-8* *M-18* *N-32* *O-14* *P-4*		Pt *K-2* *L-8* *M-18* *N-32* *O-12* *P-6*		
79 Au 197.2 *K-2* *L-8* *M-18* *N-32* *O-18* *P-1*	Au *K-2* *L-8* *M-18* *N-32* *O-17* *P-2*	Au *K-2* *L-8* *M-18* *N-32* *O-16* *P-3*					
	80 Hg 200.61 *K-2* *L-8* *M-18* *N-32* *O-18* *P-2*	81 Tl 204.4 *K-2* *L-8* *M-18* *N-32* *O-18* *P-3*	82 Pb 207.2 *K-2* *L-8* *M-18* *N-32* *O-18* *P-4*	83 Bi 209 *K-2* *L-8* *M-18* *N-32* *O-18* *P-5*	84 Po (210) *K-2* *L-8* *M-18* *N-32* *O-18* *P-6*	85 —	86 Rn 222 *K-2* *L-8* *M-18* *N-32* *O-18* *P-8*
87 —	88 Ra 225.95 *K-2* *L-8* *M-18* *N-32* *O-18* *P-8* *O-2*	89 Ac *K-2* *L-8* *M-18* *N-32* *O-18* *P-8* *O-3*	90 Th 232.15 *K-2* *L-8* *M-18* *N-32* *O-18* *P-8* *O-4*	91 Pa *K-2* *L-8* *M-18* *N-32* *O-18* *P-8* *O-5*	92 U 238.17 *K-2* *L-8* *M-18* *N-32* *O-18* *P-8* *O-6*		